SHORE EROSION STUDY

TECHNICAL REPORT

APPENDIX 1

SHORELINE EROSION AND BLUFF STABILITY ALONG LAKE MICHIGAN AND LAKE SUPERIOR SHORELINES OF WISCONSIN

KENOSHA COUNTY

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T. Edil

B. Haas

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WISCONSIN COASTAL ZONE MANAGEMENT

This report has been prepared through the cooperative efforts of the Wisconsin Geological and Natural History Survey, the University of Wisconsin (Madison, Milwaukee, Parkside and Extension), the Wisconsin Department of Natural Resources and the Office of State Planning and Energy. Assistance was further provided by Owen-Ayers and Associates.

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INTRODUCTION

This Appendix provides detailed information on shoreline conditions within much of the county. The order of materials in the Appendix is from south to north. Parts of the shoreline are broken down by reach (see County Map) and geographic section within each reach. There is a text which describes the characteristics of shoreline conditions at the beginning of each reach section. This is accompanied by a map of the whole reach which shows the sections, public perception of erosion hazards, shore damage in 1952, short- and long-term recession rates, bluff height, shore protection structures, houses per mile, and boat ramps.

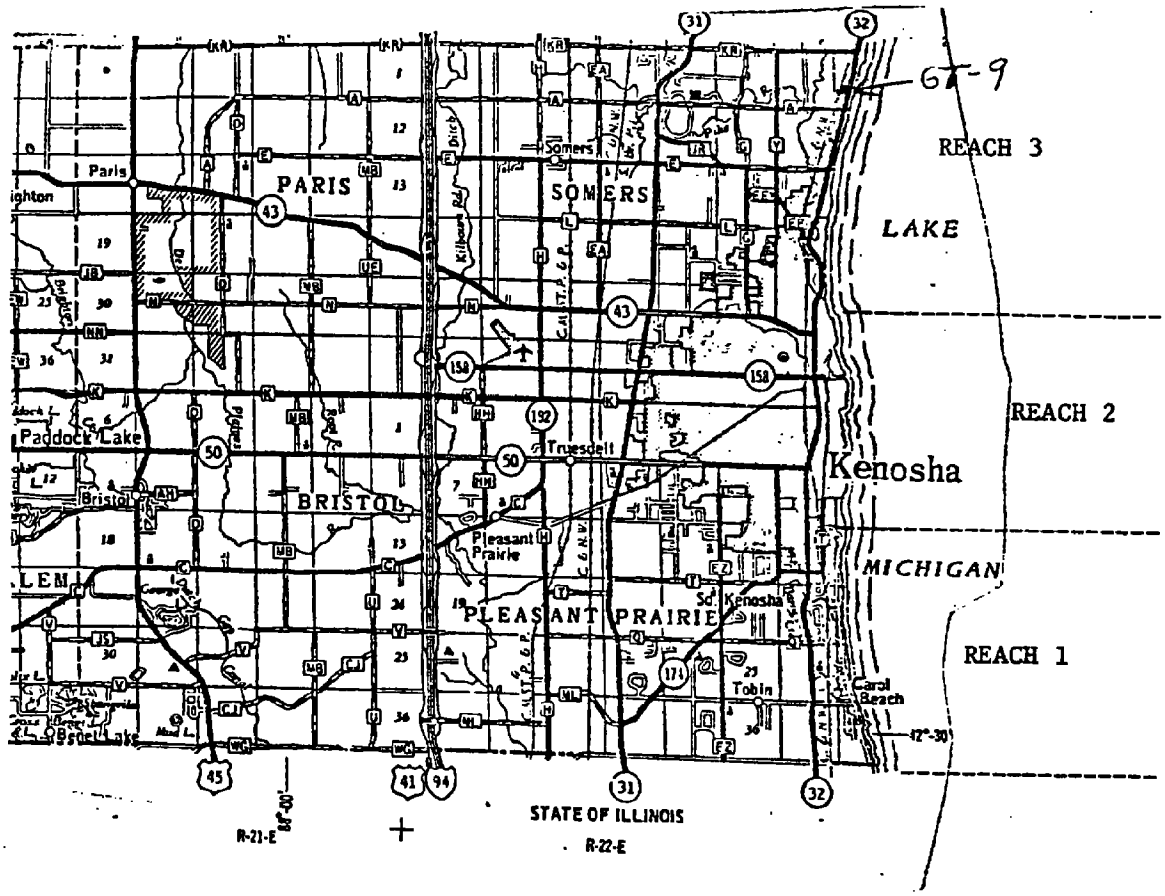
Location of geotechnical borings is indicated on the county map at the beginning of the Appendix. Logs for geotechnical holes and detailed location maps are given at the end of all of the maps in the reach containing that geotechnical site. For each geographic section (one mile long) a map showing the location of shore protection structures which are numbered and described in reports on file with the Department of Natural Resources. Also on the map, locations of measured profiles are shown along the shoreline. A running description of bluff characteristics, materials making up the toe of the slope, and beach characteristics is also given. Engineering data such as safety factor, the confidence level on this safety factor, and the distance the slope must retreat to attain a stable slope angle is also given. It should be noted that this distance assumes no wave cutting at the base of the bluff. This distance is referred to in the text as a stable slope distance. Also included with each section is a set of profiles from the water's edge to the bluff top. These profiles show stratigraphy, slope angles, circles of failure, and calculated safety factors along the shoreline. The dis-

tance to a 5 foot depth of water is also given. The date when the profile was measured is also given. Remember that the bluff profile could have changed since the profiles were measured.

The meaning of abbreviations used in the Appendix is given on this page. For more detailed description of the methods used in compiling the data, regional interpretations, and conclusions about the engineering characteristics and types of slope failure taking place refer to the main report (Shoreline Erosion and Bluff Stability Along Lake Michigan and Lake Superior Shorelines of Wisconsin) available from the State Planning Office and the Wisconsin Geological Natural History Survey.

Symbols Used
(used as nouns and adjectives)

b	boulders
c	clay or clayey
co	coarse
f	fine
g	gravel
m	medium
p	pebbles
s	sand
si	silt
t	till
y	cobbles
t(1A)	till name
SF	Factor of Safety A - unsatisfactory (1.00) B - questionable (1.00-1.25) C - satisfactory (1.25)
CL	Confidence Level A - high confidence - at borehole B - medium confidence - near borehole, stratigraphy visible C - low confidence - away from borehole, stratigraphy questionable
SL	Stability line - the distance slope must retreat to attain a stable slope angle. This assumes no erosion at toe and unchanged conditions of nature of material and water table.



KENOSHA CO.
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STATE OFFICE BUILDING
Madison, Wisconsin
SCALE 0 1 2 MILES

Reach 1

Erosion reach 1 of the Lake Michigan shoreline is located in southern Kenosha County, in Township 1 North, Range 23 East. The reach is about 4½ miles long and extends from the Illinois state line on the south to the Kenosha city limits on the north; it thus includes the entire stretch of shoreline known locally as Carol Beach. This 4½-mile segment is considered to be the most critical reach of the entire Lake Michigan coast in terms of shore damage and recession rates; it has the highest priority of all reaches, with a per-mile value of 32.

The northernmost half-mile of the reach (in section 8) is owned by the Wisconsin Electric Power Company and is currently unused except by trespassing motorcycle enthusiasts, who have desecrated a beautiful and scientifically valuable area of coastal sand dunes and adjoining natural prairie. Except for this power company property and the Trident Marina development at the extreme south end of the reach, the entire reach is subdivided into residential lots, a fairly high proportion of which are vacant. The density of houses is thus considerably lower than in some other non-urban segments of the shoreline, but new home construction was apparent during the summer of 1976. In contrast, during the past few years a number of houses have been destroyed as a result of shoreline recession or have been relocated in order to prevent their destruction.

Beach widths in Reach 1 range from 0 to about 110 feet. Variations in beach width over short distances are common throughout the reach, most of the changes being controlled by shore protection structures. In one area, for example (in section 32), the beach widens from 15 feet to 110 feet in less than a quarter-mile; at another locality, the width increases from 10 to 100 feet in a still shorter distance. In both situations virtually no beach is present immediately to the north or south. Man's extensive

modification of the shoreline coupled with the effects of shoreline recession are largely responsible for these changes. Natural beach materials everywhere consist mostly of sand with smaller quantities of gravelly constituents (pebbles and small cobbles).

The bluff in this reach is low. Typically, it is only 4 or 5 feet high and nowhere does its height exceed 20 feet. In many places a bluff, as such, does not actually exist, the rise from lake level to the upland surface being nothing more than a gentle beach slope. In other places, however, a distinct bluff is present, generally ranging in height between 5 and 10 feet. The highest bluff occurs in section 17 at the north end of the Carol Beach area adjacent to the power company property, where the bluff is 18-20 feet high (see profile 1, section 17).

Throughout this entire reach, the bluff is composed of fine- to coarse-grained sand. Genetically, most of the sand is beach sand deposited during a much earlier and higher lake stage, but in some places, particularly where the bluff is higher, the upper part of the bluff is made of dune sand (see profiles 1 and 2, section 17). Thin organic horizons, mostly organic sands, are interbedded with the beach sands at several exposures (see profiles 1 and 2, section 17 and profile 1, section 20). No deposits of till or fine-grained lacustrine deposits were observed in any of the bluff exposures. Several years ago, before the present period of high lake level came into existence, silty clay till was exposed just above lake level at the extreme north end of the reach in the middle of section 8 on the Wisconsin Electric Power Company property. A 4½-inch power auger hole drilled in October 1976 at the site of profile 2 in section 20 failed to encounter any till, however, to a depth of approximately 30 feet below lake level.

Shore protection structures are very abundant in Reach 1. Approximately 175 such structures were identified and described, despite the fact that a

single structure — a newly constructed dolomite rip-rap revetment — protects the shore for the full half-mile of the electric company's shoreline at the northern end of the reach. For the remaining 4 miles of the reach, the density of protective structures averages about 42 per mile; in one section alone (section 17) there are nearly 60 individual shore protective devices. This is undoubtedly the highest density of individual structures along the entire Wisconsin coast.

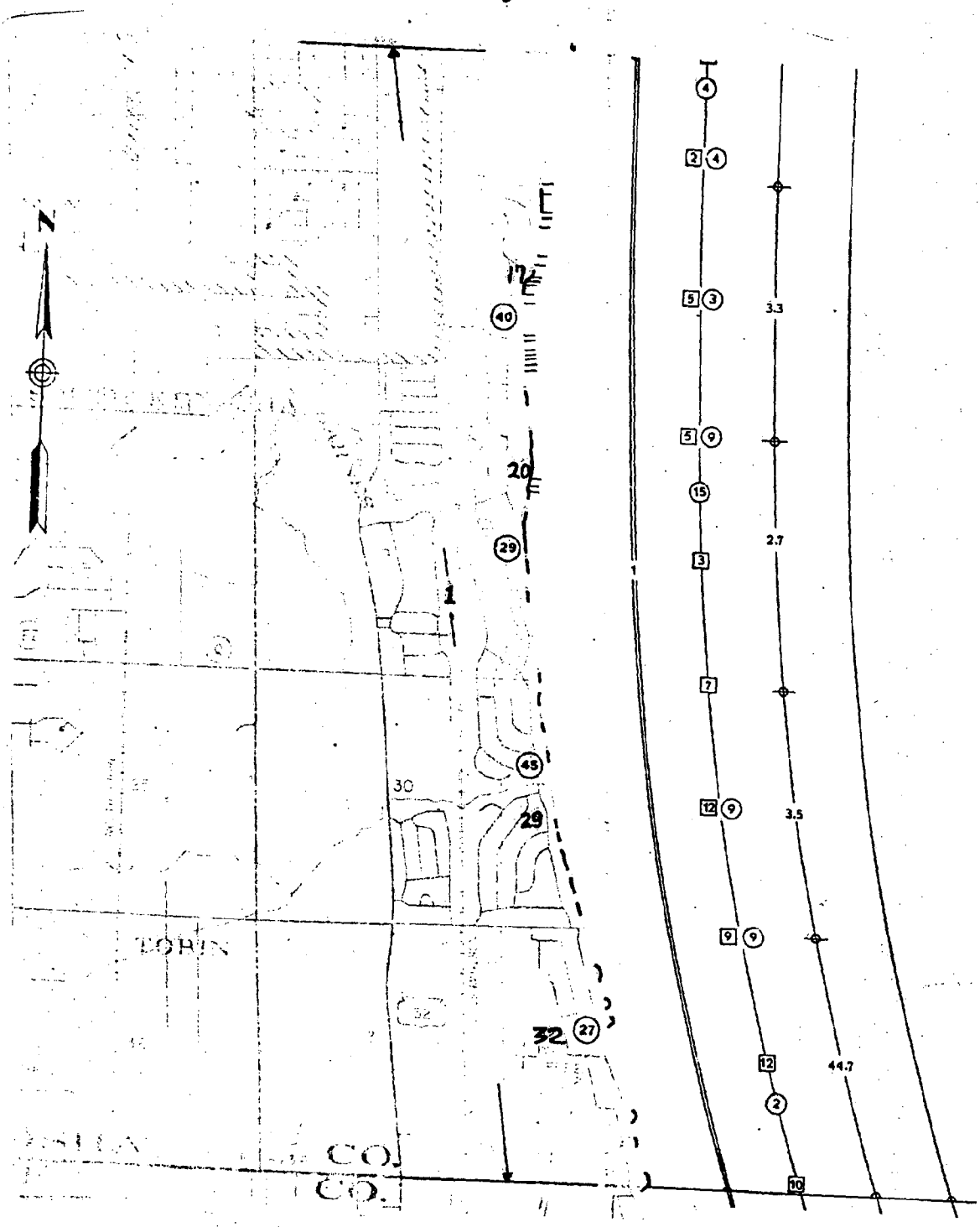
Slope failures in Reach 1 occur mainly through the mechanism of slump, induced by oversteepening of the bluff face by wave action at the toe. As a result, the bluff edge in many places is finely scalloped, particularly where shore protection structures are absent. Sand slides and sandflows do not appear to present a severe problem, despite the presence of seep zones within the sand units that compose the bluff (see profile 3, section 17 and profile 2, section 20).

The precise causes of the excessive shoreline erosion rates, which make this reach the most critical segment of Wisconsin's Lake Michigan coast, are difficult to pinpoint. The most important single factor is undoubtedly high lake level, and although high lake level accelerates erosion rates along the entire shoreline, it may simply have a greater effect in Reach 1 than in other reaches. A gently to moderately sloping beach, such as that which characterizes the Carol Beach area, may be largely or entirely submerged by a rise in lake level of only 1 or 2 feet. Narrowing of the beach promotes excessive erosion because storm-wave energy is directed against the toe of the bluff, rather than being mostly absorbed by the beach itself.

A second factor is undoubtedly the character of the material that composes the bluff (such as it is) in Reach 1. Being wholly unconsolidated and without natural cement to hold the sediment together, the loose sand grains are readily eroded by high-energy waves that overrun the narrowed beach and crash against the base of the upland. Because the bluff is low

and therefore does not supply the large quantity of material to its base as in high-bluff areas, the sand is quickly removed from the bluff-base or high-beach environment, thereby eliminating the presence of a buffer zone against the waves in this environment, which further accelerates the rate of shoreline recession.

Another cause of excessive erosion in this reach is the location of the reach, being just south of the City of Kenosha and its harbor structures, which serve to interrupt the longshore transport of sand along the beach; thus the sand removed from the littoral environment in Reach 1 is not replenished or balanced by an adequate inflow of sand from the north. Furthermore, there is probably little sand supplied to the beach that is derived from the land to the west. Although the upland in this area may be underlain mainly by lacustrine silts, the general absence of streams crossing the upland and entering the lake virtually eliminates the possibility of any significant sand replenishment from this direction.

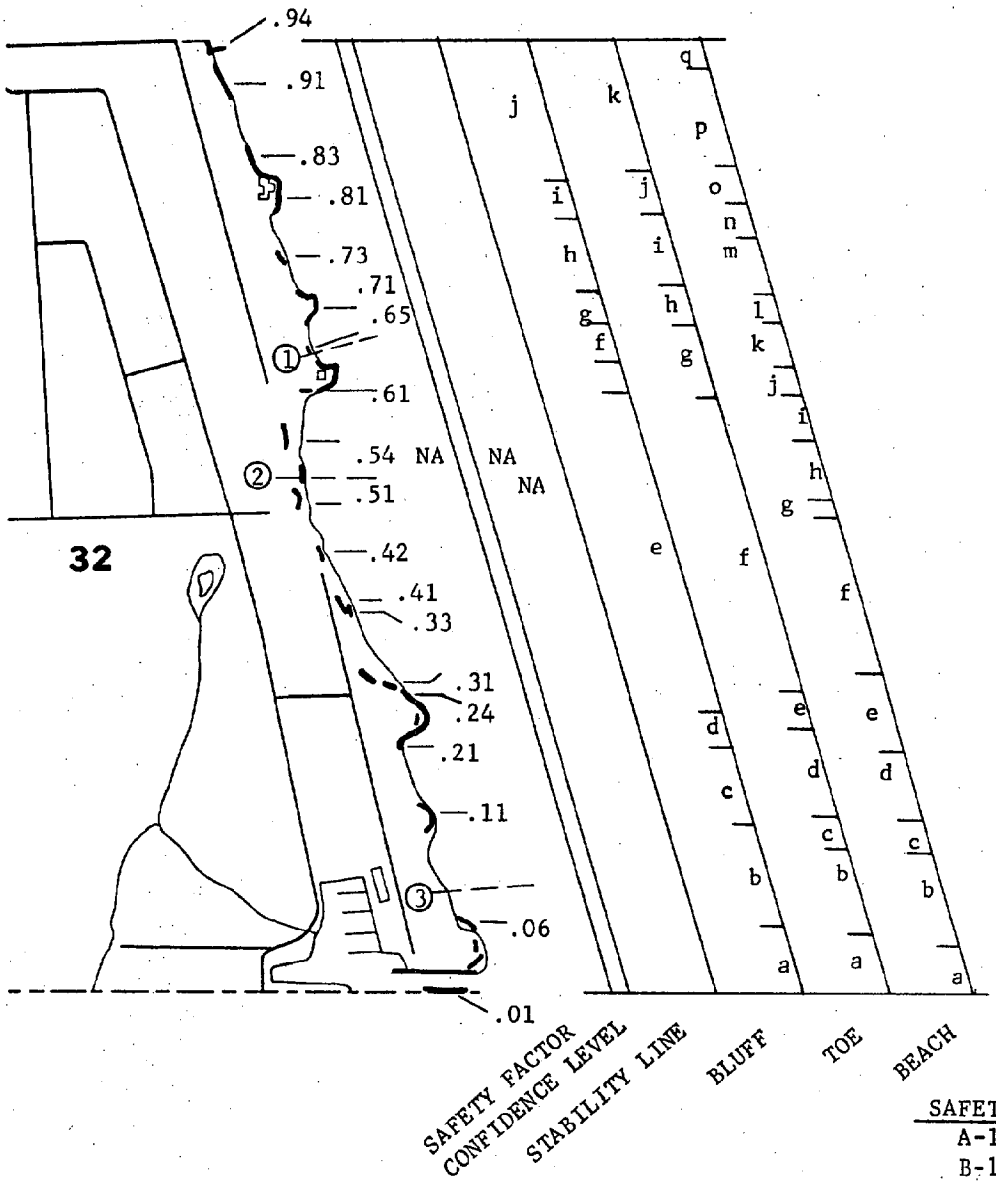


Reach 1

1 mile

PUBLIC PERCEPTION: EROSION HAZARDS { 3 Public safety, 2 Property, 1 Environment
1952 SHORE DAMAGE SURVEY —1=$10,000 (1952)
RECESSION RATES { □ Long-term-approx.100 yrs. ○ Short-term-approx.10 yrs. } (in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE-Non-urban
BOAT RAMPS

T.1N.,R.23E.,Sec.32

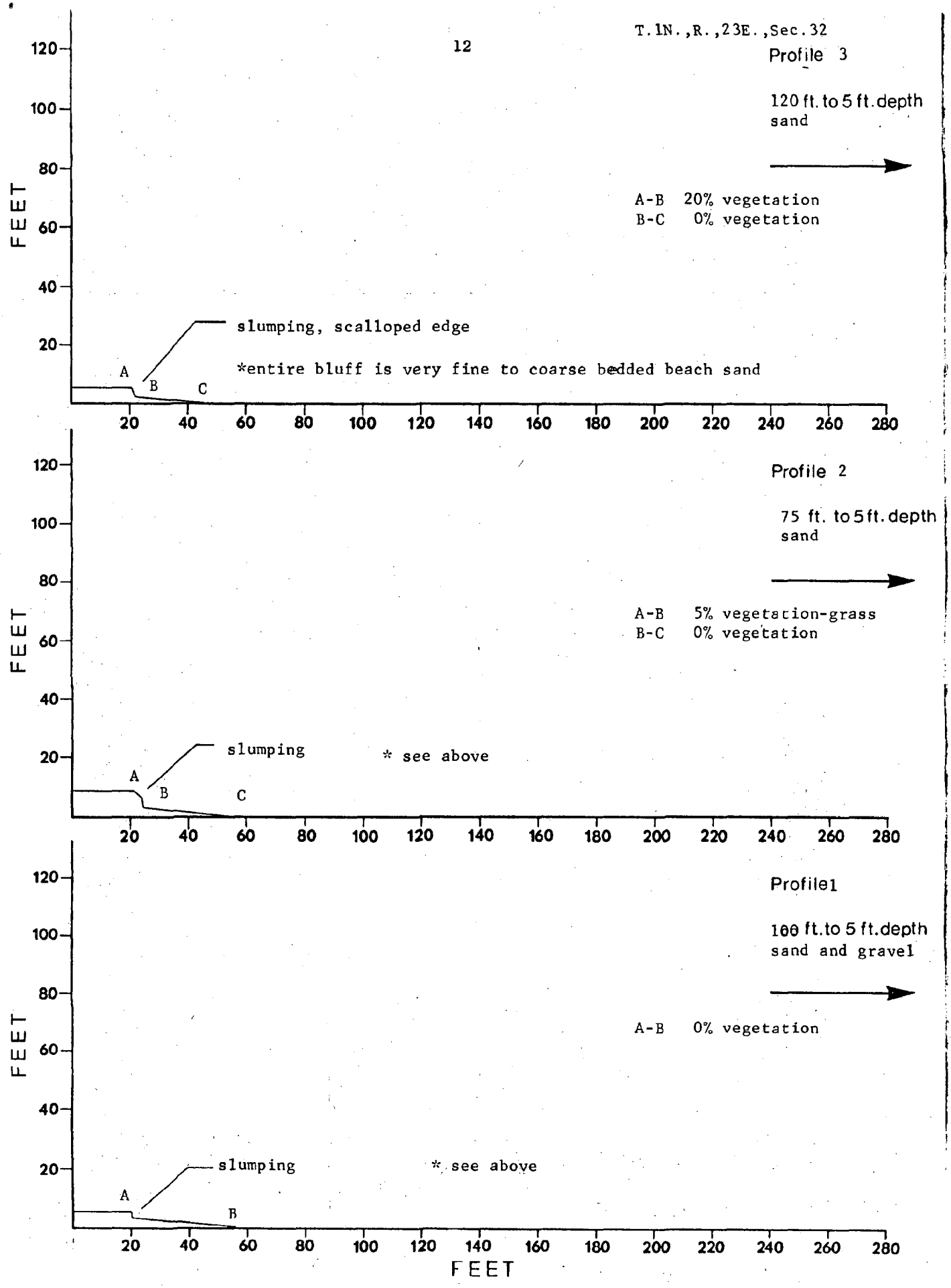


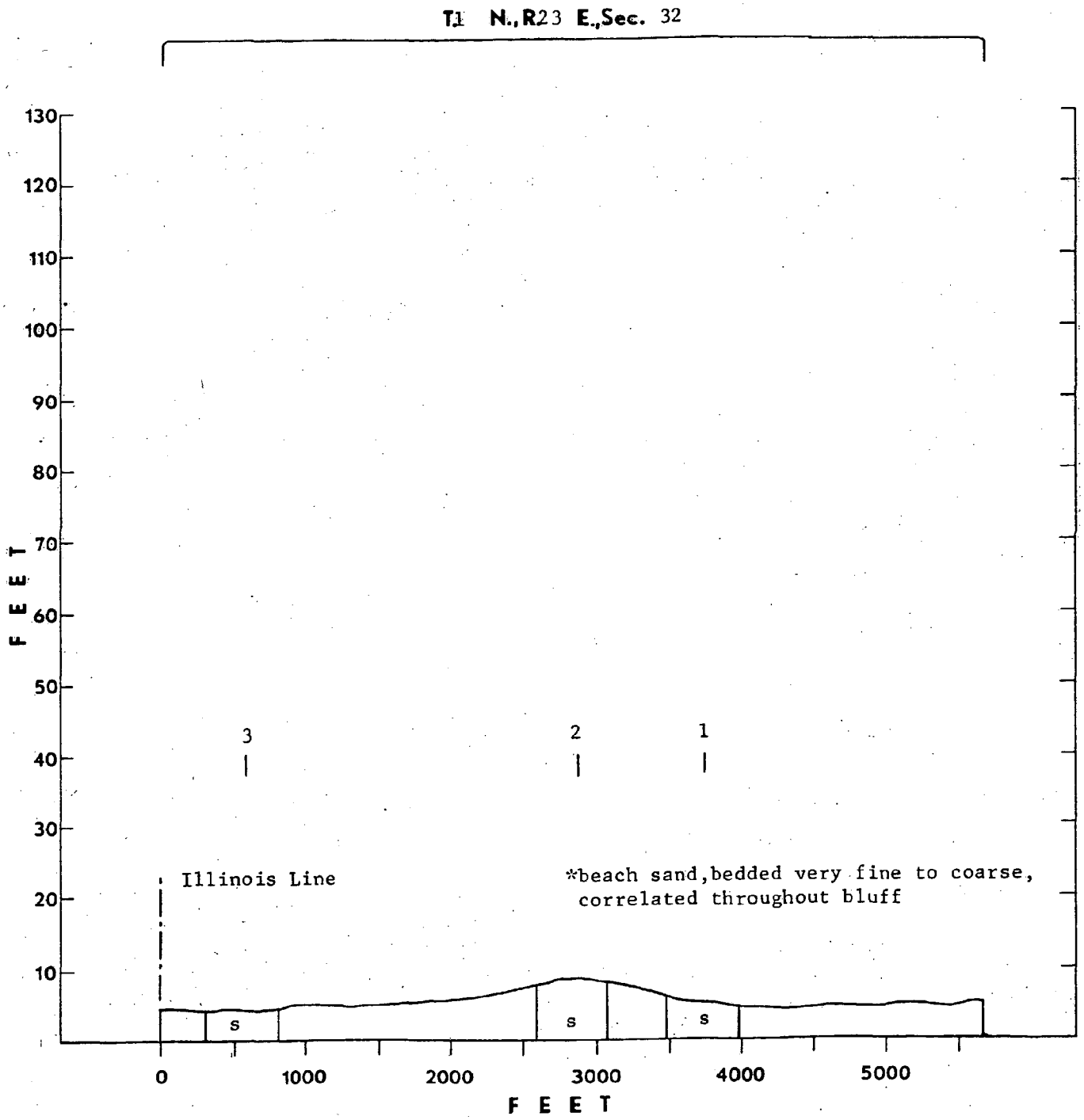
SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-structures	b-slumping and wave erosion, scalloped bluff edge	c-slump; scalloped bluff edge	d-structures
	e-slumping and wave erosion along entire stretch, scalloped bluff edge with visible slump blocks	f-structures	g-slump scalloped bluff edge sand, also wave erosion of the toe	h-stable; structures
	i-slump, wave erosion of toe	j-some erosion, but protected by structures, some slump	k-bluff is beach sand, failing by slump and wave erosion of toe, scalloped bluff edge	*entire bluff in this section is beach sand (very fine to coarse) anywhere protection is absent, there is slump and wave erosion of toe sand taking place
2. TOE	a-concealed	b-beach sand	c-concealed	d-beach sand
	e-concealed	f-beach sand	g-concealed	h-concealed
	i-beach sand	j-concealed	k-beach sand	*all toe materials are in place, very fine to medium beach sand, except where concealed by structures
3. BEACH	a-no beach	b-20 to 40 ft. sand and gravel	c-no beach	d-30 to 50 ft. sand, some gravel
	e-no beach	f-beach widens steadily 15ft. at north,110 ft. at south of segment, sand and some gravel	g-no beach	h-20 to 30 ft. sand and gravel
	i-60 to 90 ft. sand and gravel	j-no beach	k-20 to 40 ft. sand and gravel	l-no beach
	m-20 to 40 ft. sand and gravel	n-100 ft. sand	o-no beach	p-10 to 100 ft. sand and gravel widens southward
	q-0 to 5 ft. sand and gravel			

T.1N.,R.,23E.,Sec.32

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*beach sand, bedded very fine to coarse, correlated throughout bluff
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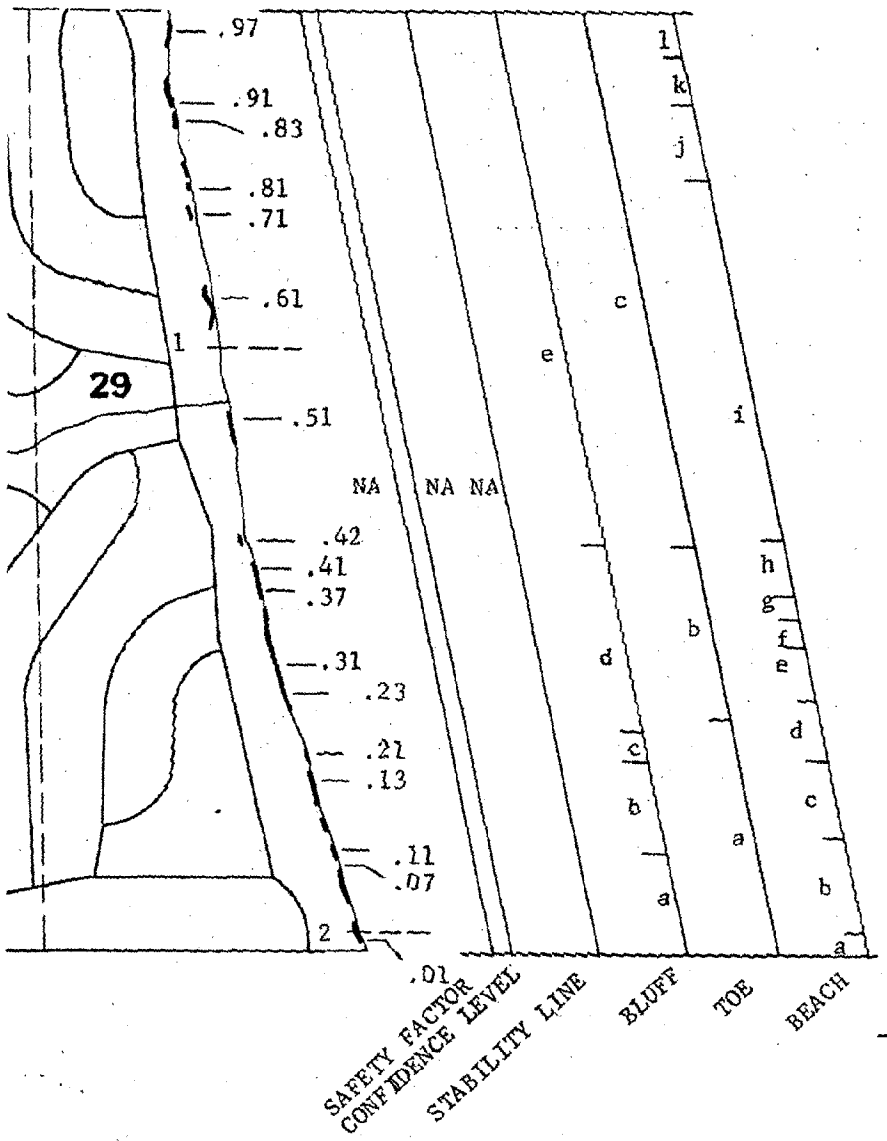
T.1N.,R.23E.,Sec.29

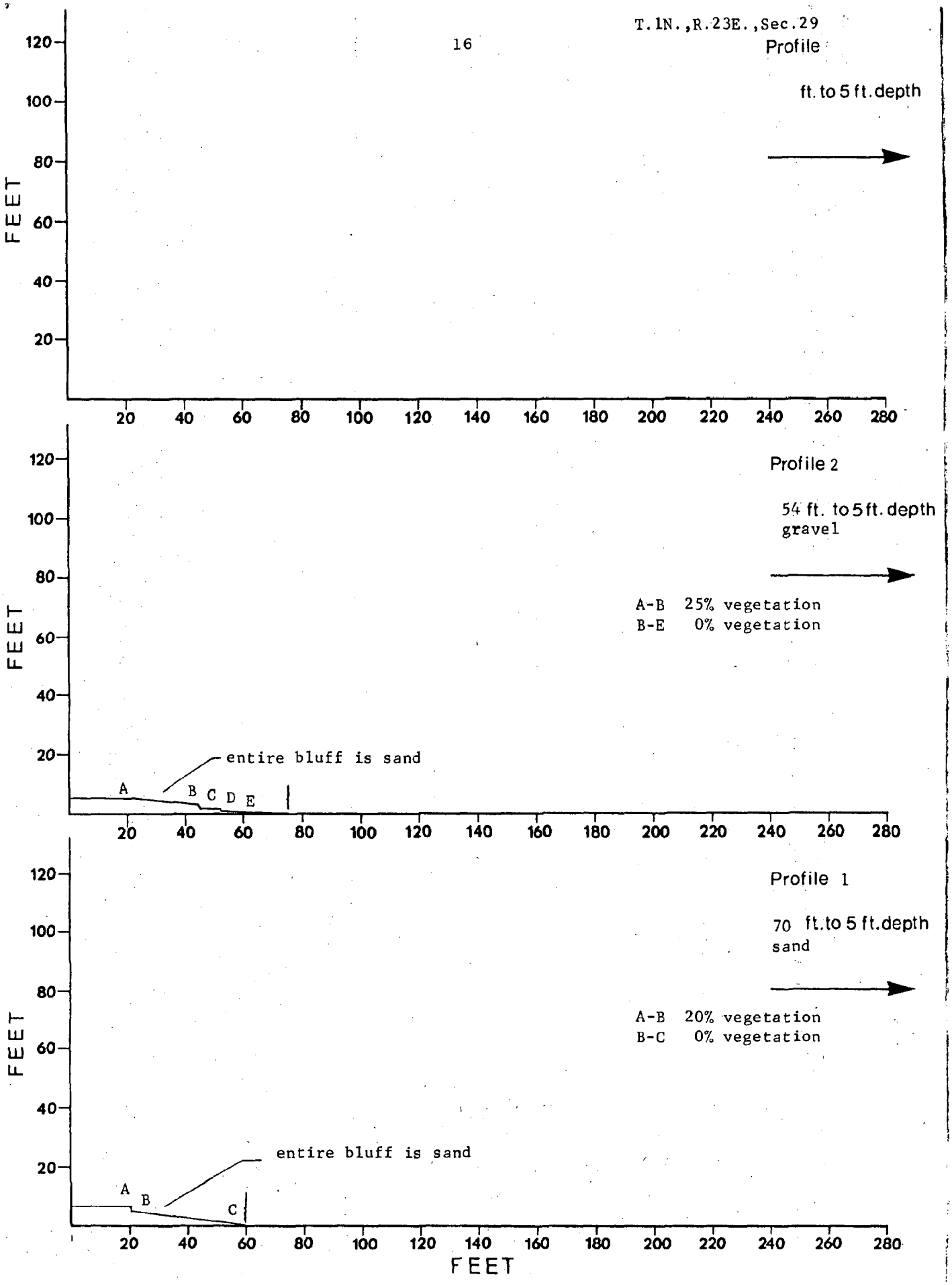


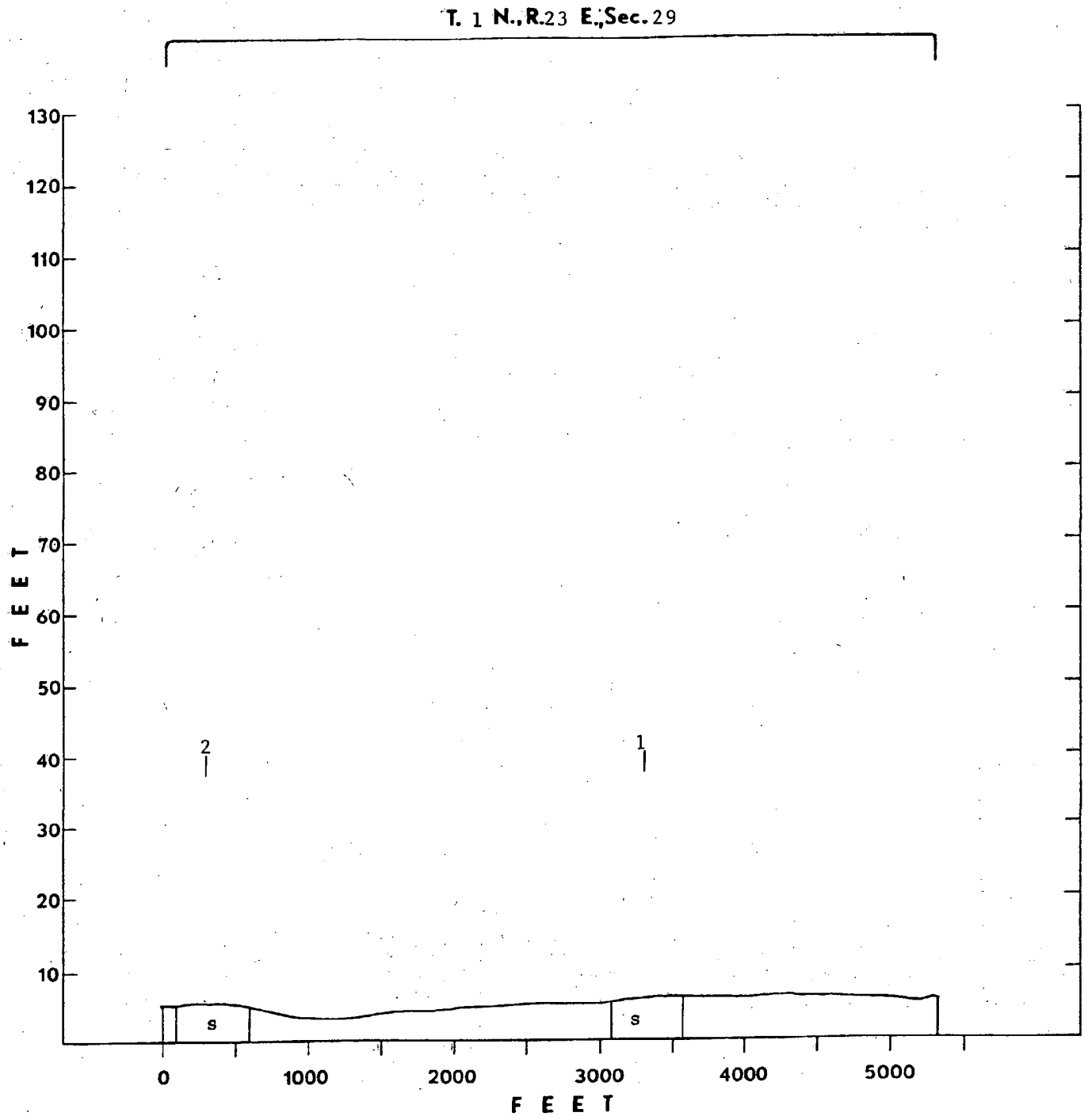
SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-beach sand, eroding by slump and wave action.	b-beach sand protected by structures	c-beach sand slumping	d-fairly stable bluff is beach sand protected by structures
	e-scalloped bluff edge, total height 4 to 6 ft., all composed of beach sand -sand is slumping in most areas and also being lost through wave erosion-swallows also weaken bluff by boring numerous deep holes laterally into bank for nests. Sand is very fine-coarse beach sand.			
2. TOE	a-beach sand	b- beach sand; mostly concealed by structures	c-beach sand	
3. BEACH	a-less than 5 ft. gravel	b-10 to 20 ft. sand and gravel	c-no beach	d-20 to 35 ft. sand and gravel
	e-20 ft. sand and gravel	f-no beach	g-65 ft. sand and some pebbles	h-no beach
	i-40 to 100 ft. sand and some cobbles	j-40 ft. sand and cobbles	k-no beach; structures present	1-25 to 30 ft. sand and gravel

T.1N.,R.23E.,Sec.29

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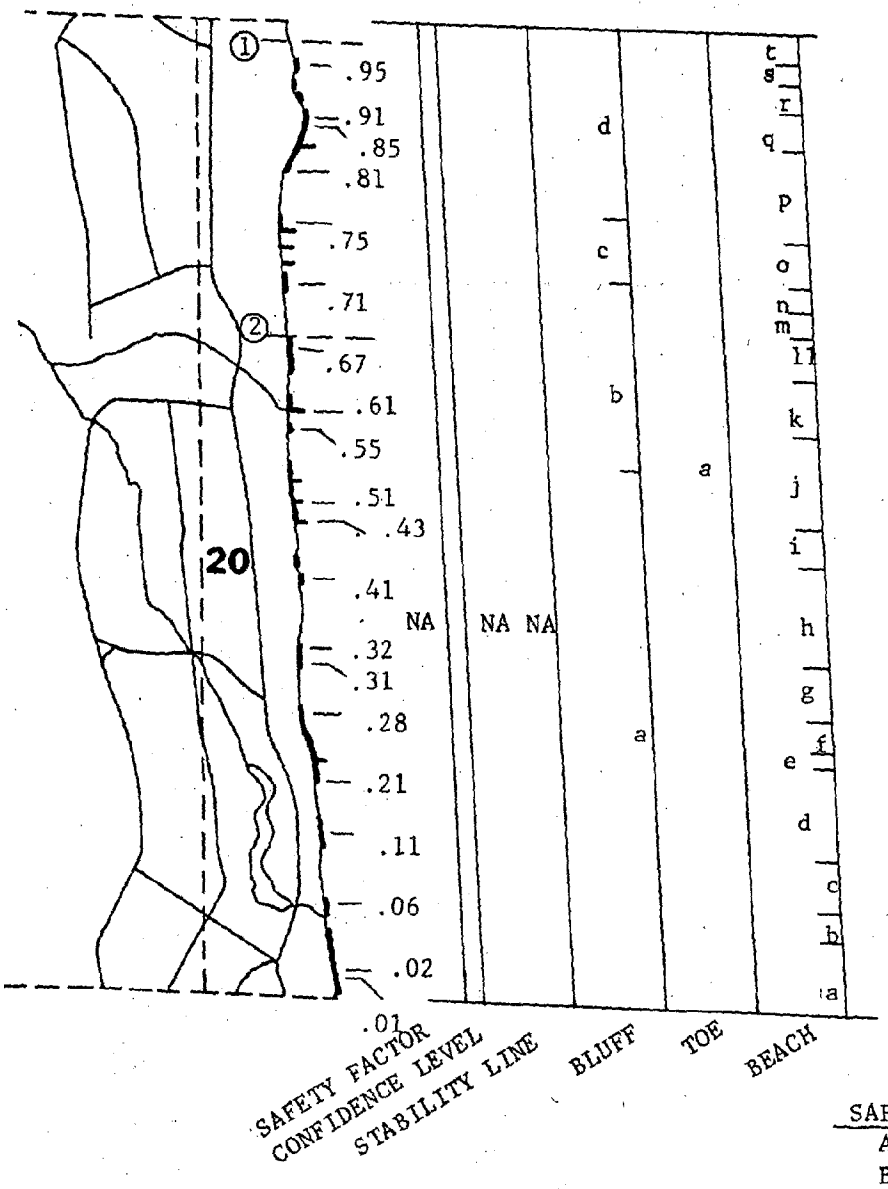

SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high Confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low cinfidence)

1. BLUFF	a-generally sand, 4 to5 ft. high, failure by slumping and wave erosion where not protected by structures	b-area of slumping and sloughing, bluff edge is scalloped from slumps caused by wave erosion of toe	c-groin field, bluff is fairly stable and vegetated; sand	d-sand, 5 ft. high failure by slump;scalloped edge where not protected by structures
2. TOE	a-toe of bluff is sand, generally very fine to coarse laminated beach sand, except where concealed by structures			
3. BEACH	a-no beach	b-30 to 40 ft. sand and cobbles	c-5 to 10 ft. sand and some gravel	d-no beach
	e-less than 5 ft. sand	f-no beach	g-10 ft. sand and gravel	h-15 ft, sand and gravel
	i-10 to 15 ft. sand	j-no beach all structures some small beach areas of less than 5 ft.	k-50 ft sand, some pebbles	1-no beach
	m-20 ft. sand and gravel	n-less than 5 ft. sand	o-50 to 75 ft. sand; some gravel	p-20 to 25 ft. sand and gravel
	q-no beach	r-5 to 10 ft. sand and gravel	s-no beach	t-10 to 15 ft. sand and gravel

T.1N.,R.23E.,Sec.20

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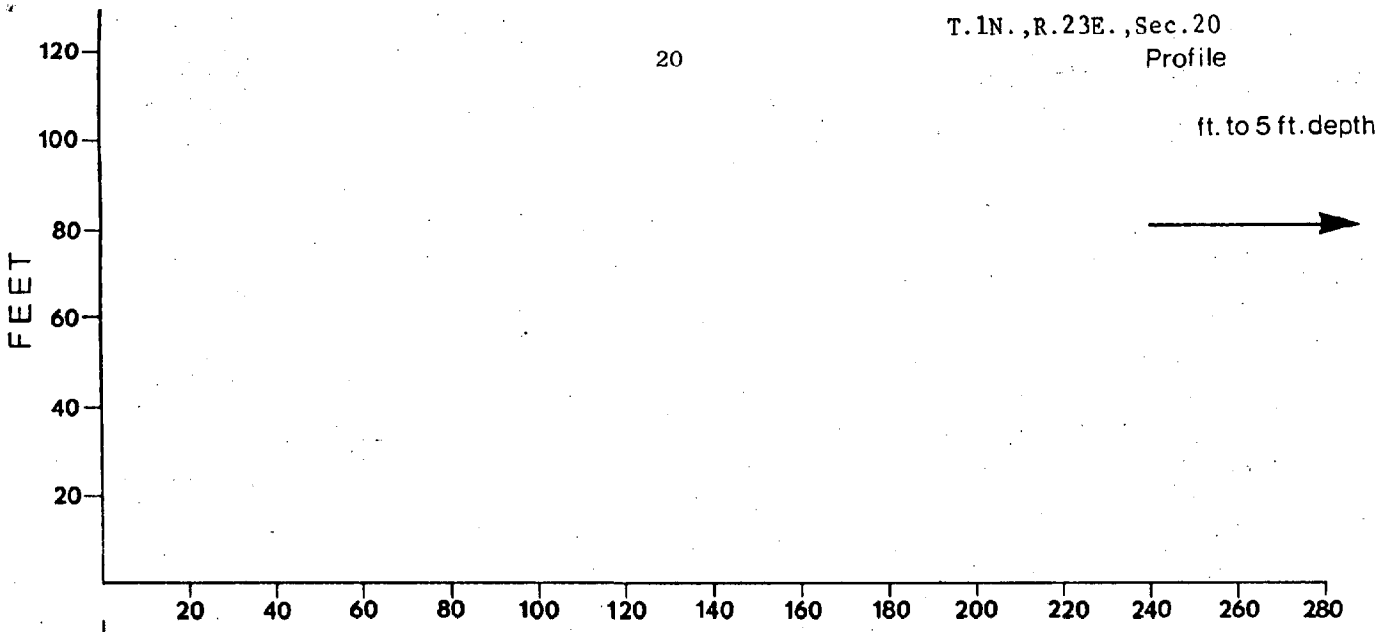
Profile

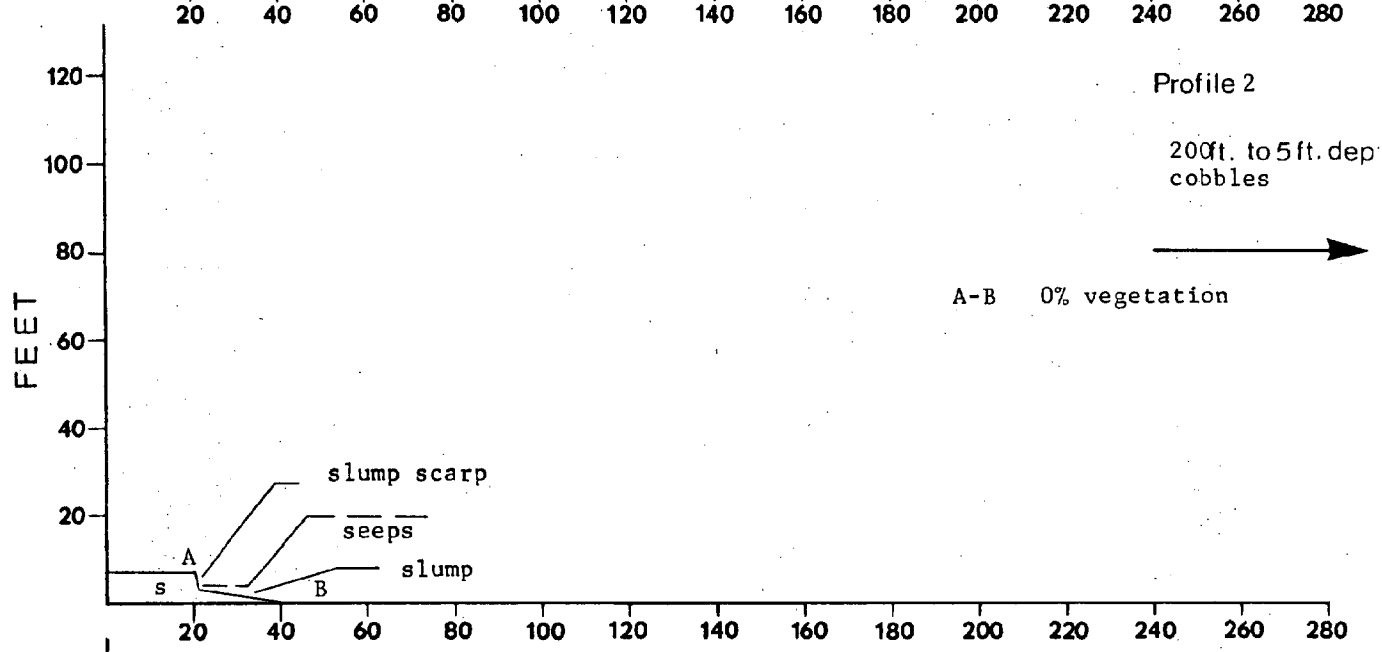
ft. to 5 ft. depth



Profile 2

200ft. to 5 ft. dep
cobbles

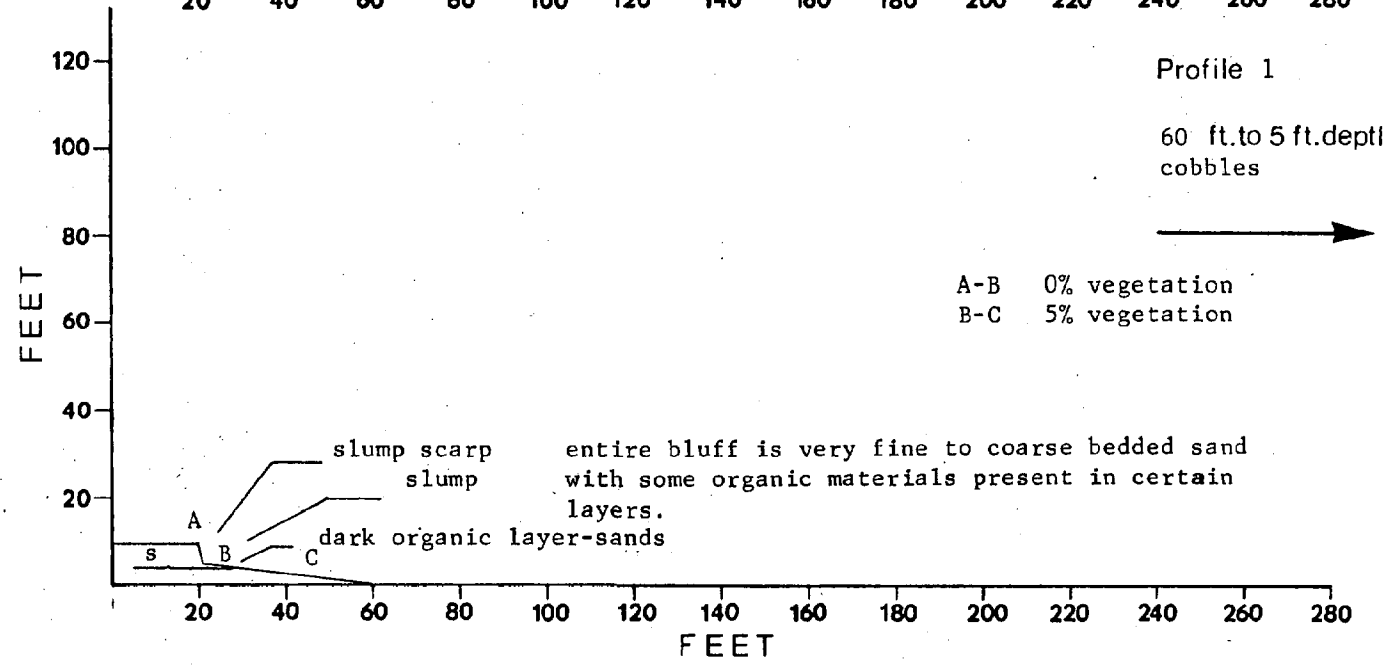
A-B 0% vegetation



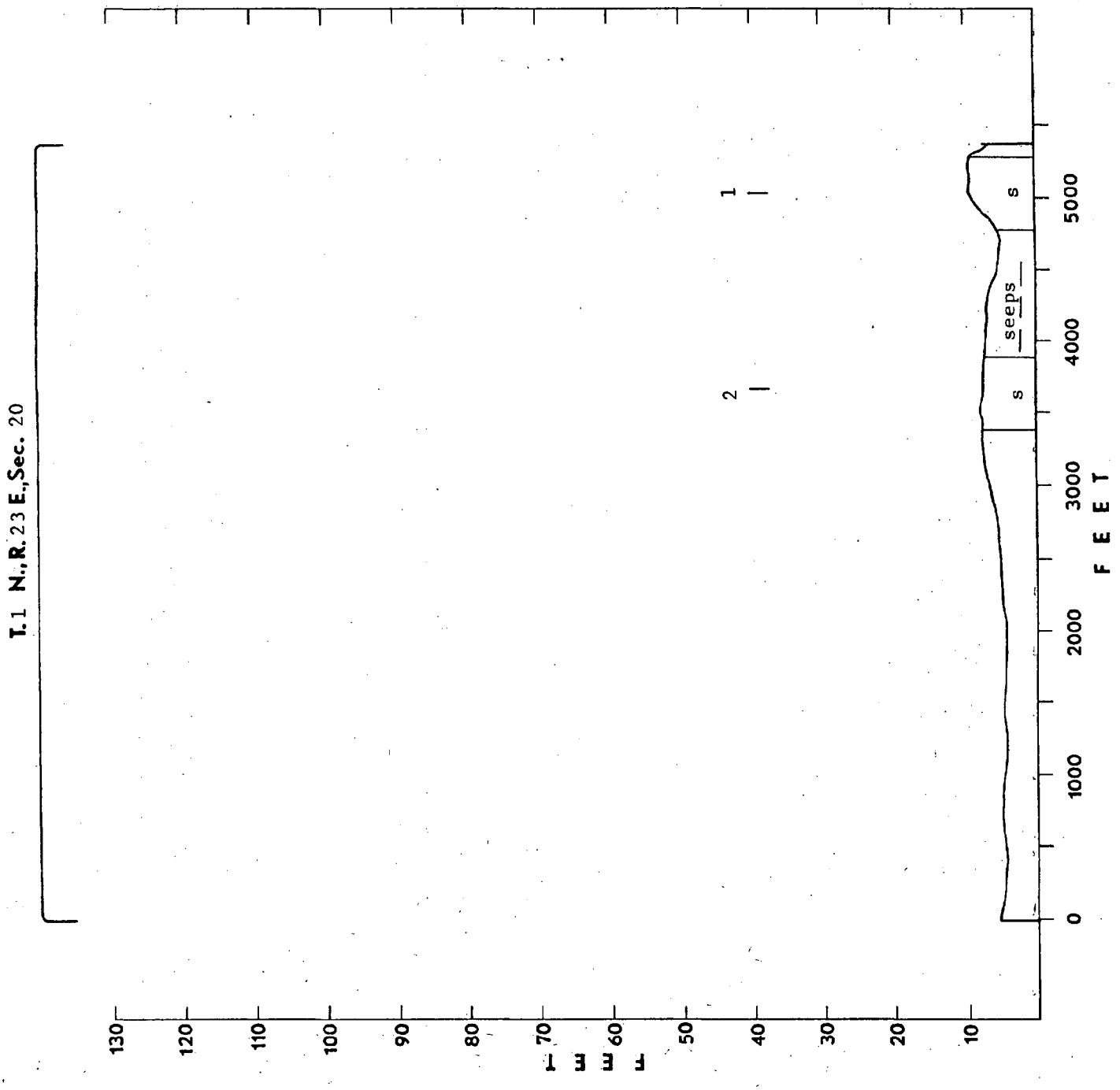
Profile 1

60 ft. to 5 ft. depth
cobbles

A-B 0% vegetation
B-C 5% vegetation



entire bluff is very fine to coarse bedded sand with some organic materials present in certain layers.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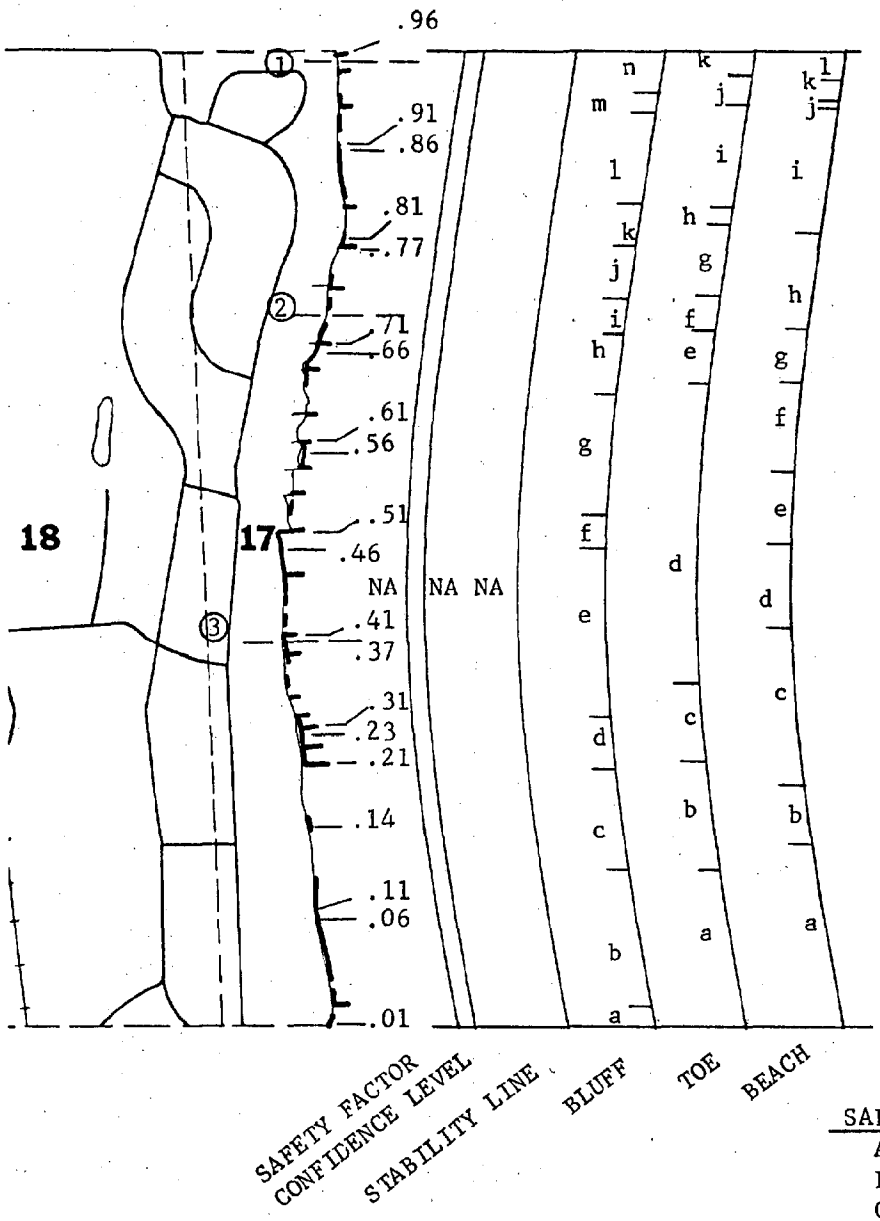


SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy v visible (low confidence)

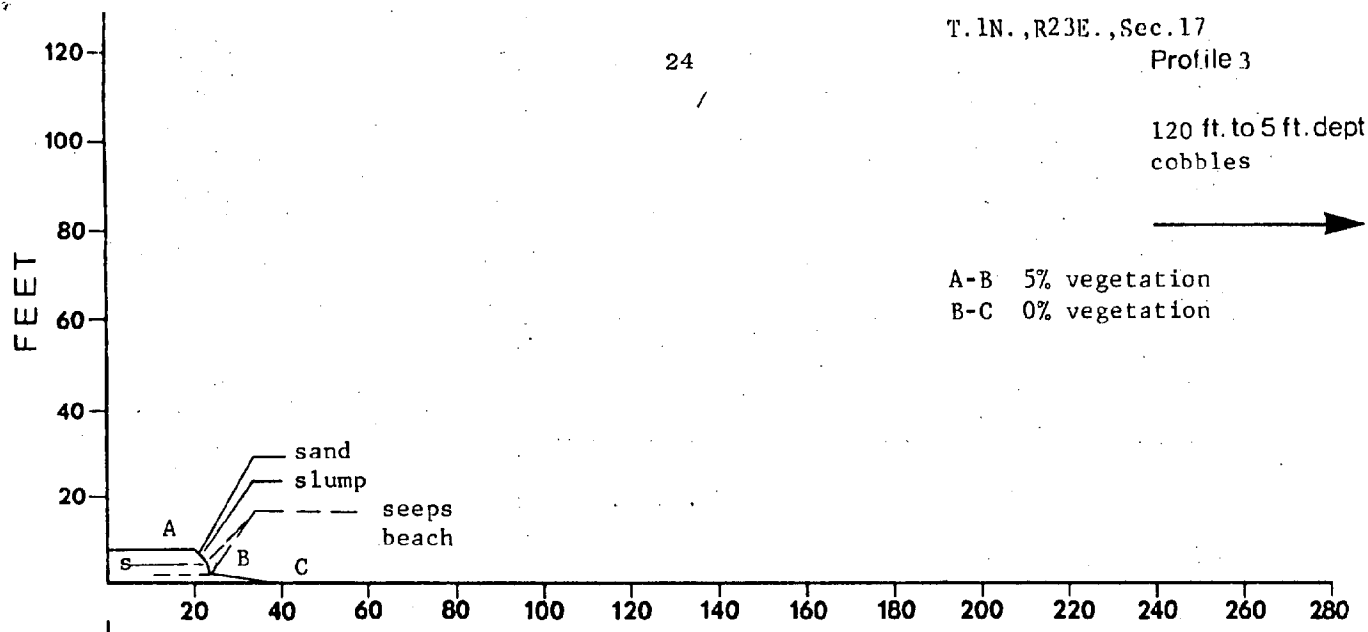
1. BLUFF	a-minor slumping; sand	b-fairly stable protected with structures, well vegetated	c-slumping area scalloped bluff edge sand	d-fairly stable
	e-scalloped bluff edge slumping sand seep zones in lower part of profile 3	f-slumping sand	g-bluff fairly stable;long beaches fairly well vegetated	h-mostly concealed some sand visible, fairly stable with structures
	i-sand;slumping	j-concealed	k-sand,slumping scalloped bluff edge	l-concealed with dolomite structures
	m-sand, scalloped bluff edge; slumps	n-sand± 20 ft. slumping		
2. TOE	a-concealed by vegetation and structures	b-sand, slumping or in place, fine to medium bedded beach sand	c-concealed, lawns, structures	d-sand, fine to coarse layered, beach,slumped or in place
	e-concealed	f-sand, layered, beach	g-concealed, structures, vegetation and fill	h-sand
	i-concealed; structures, some fill	j-concealed, sand	k-sand,slump or in place	
3. BEACH	a-no beach	b-15 to 20 ft. sand and gravel	c-20 to 30 ft. sand;some gravel	d-5 to 10 ft. sand and gravel
	e-25 to 35 ft. sand and gravel	f-less than 40 ft. sand and gravel	g-no beach	h-less than 30 ft. sand and gravel, narrows toward south to 10 ft.
	i-no beach	j-40 ft. sand and gravel	k-no beach	l-40 to 50 ft. primarily sand; some gravel

T.1N.,R23E.,Sec.17

Profile 3

120 ft. to 5 ft. depth
cobbles

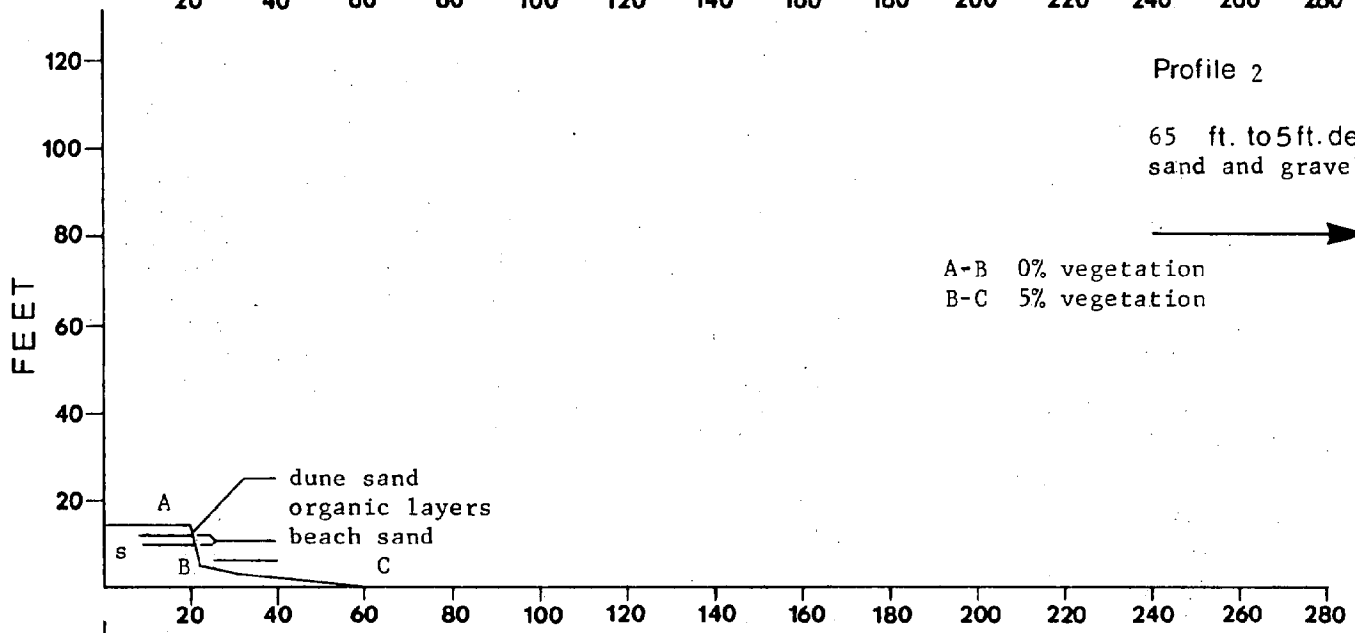
A-B 5% vegetation
B-C 0% vegetation



Profile 2

65 ft. to 5 ft. depth
sand and gravel

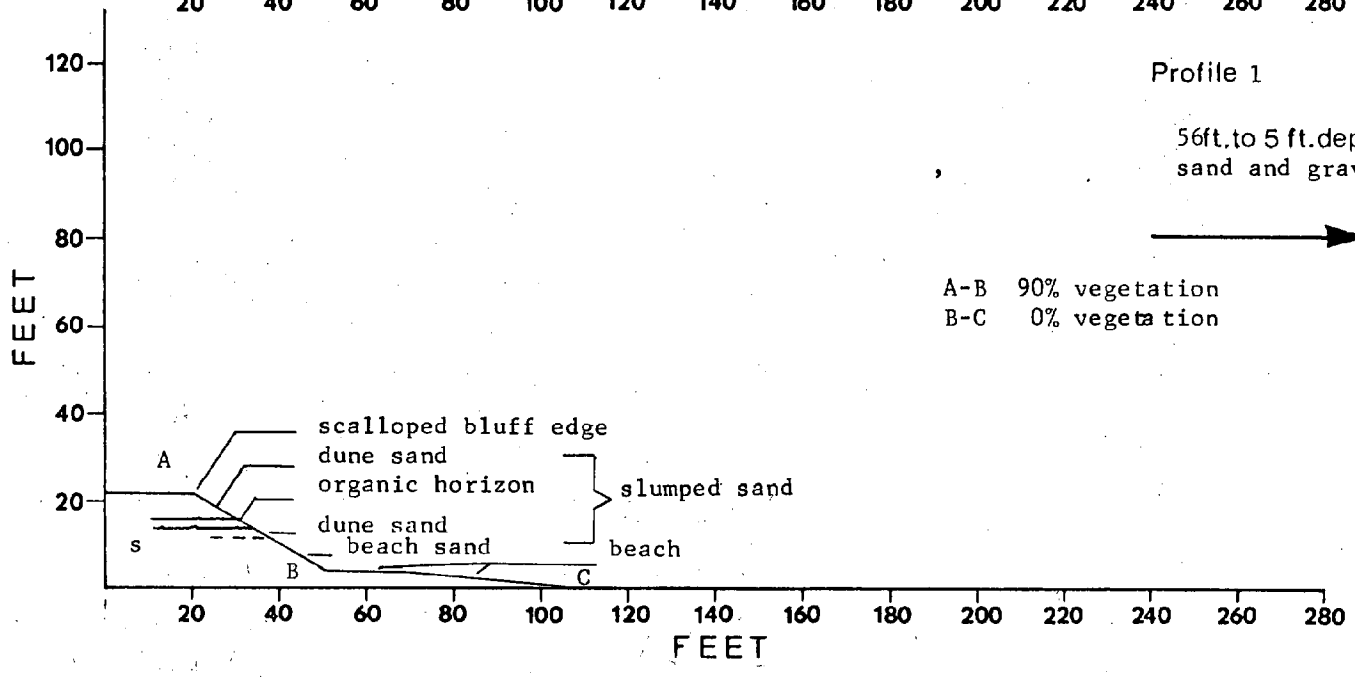
A-B 0% vegetation
B-C 5% vegetation

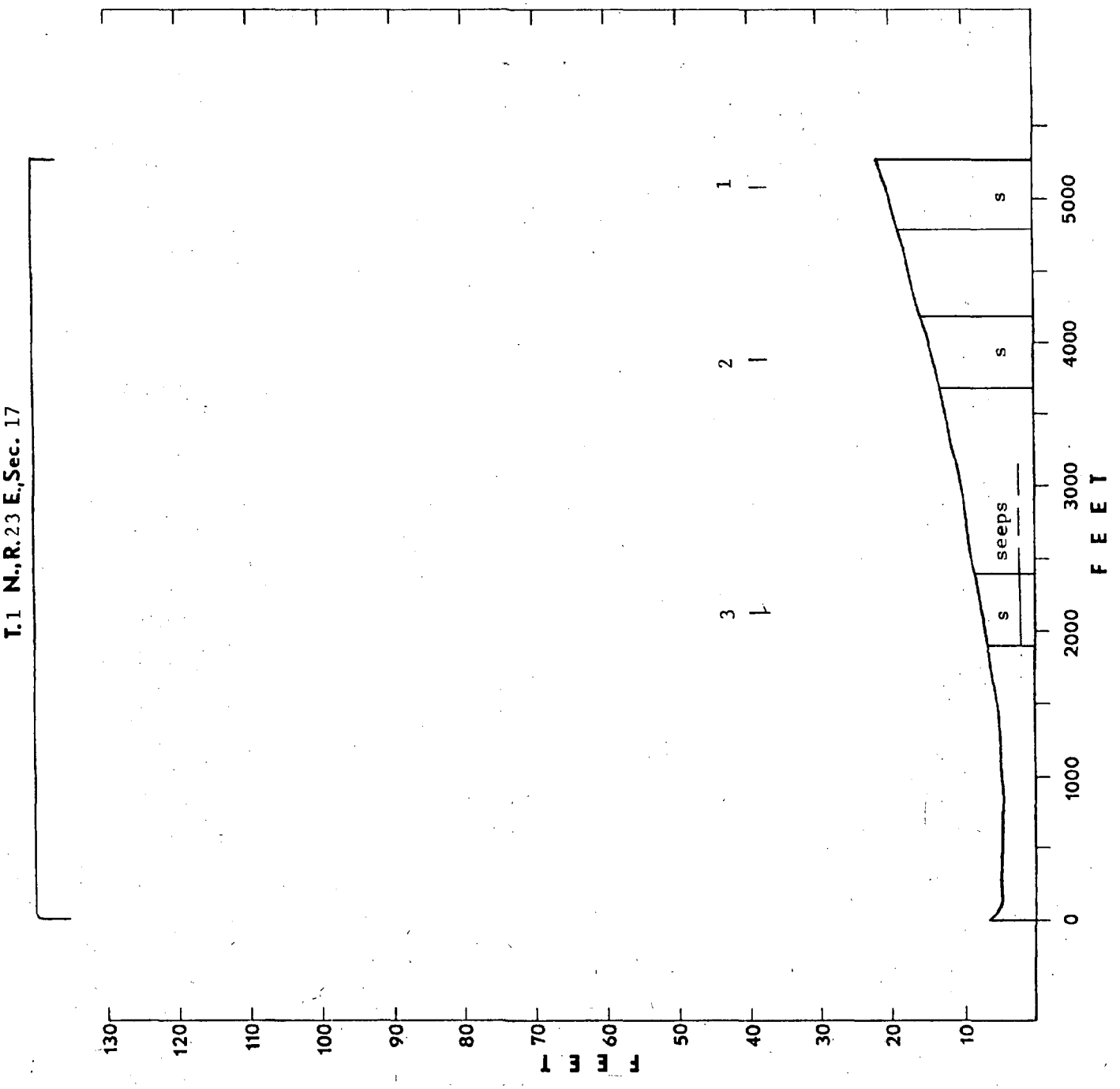


Profile 1

56ft. to 5 ft. depth
sand and gravel

A-B 90% vegetation
B-C 0% vegetation

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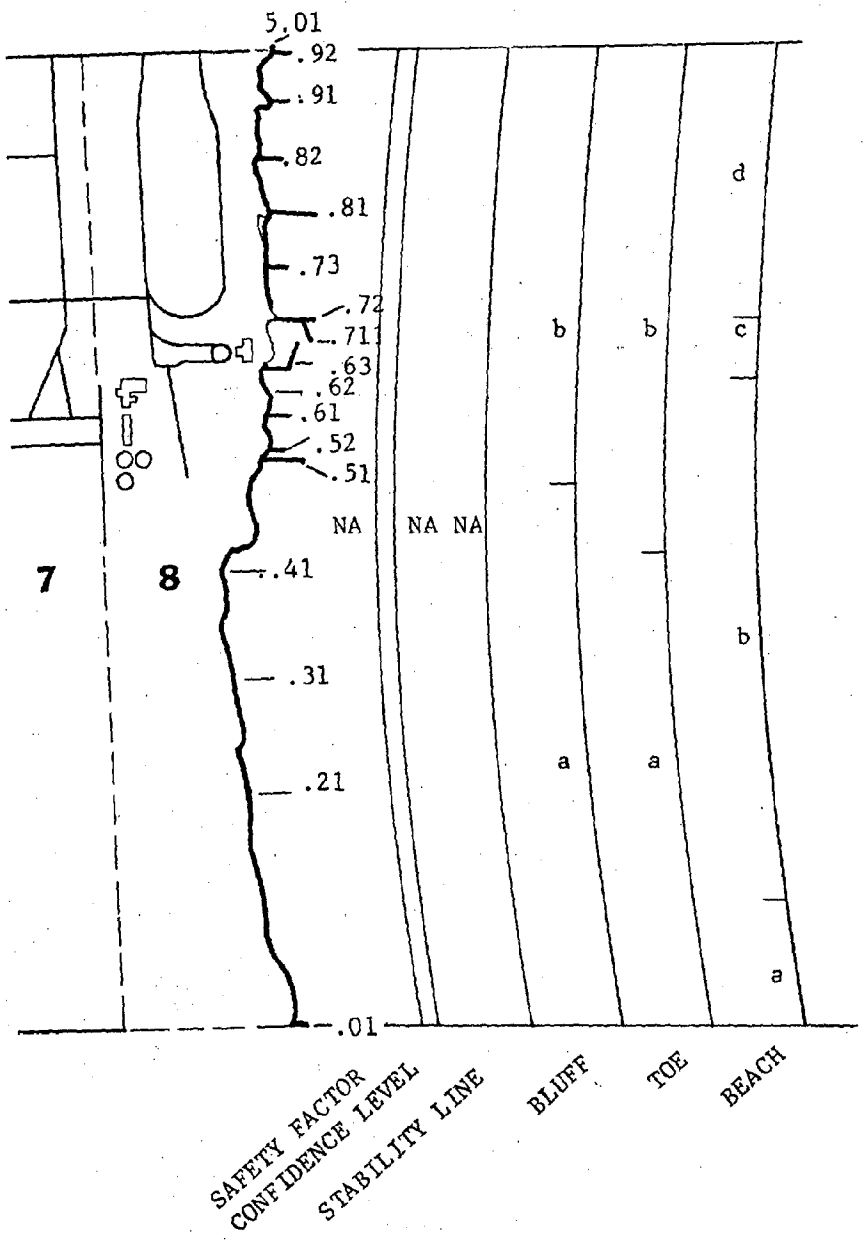
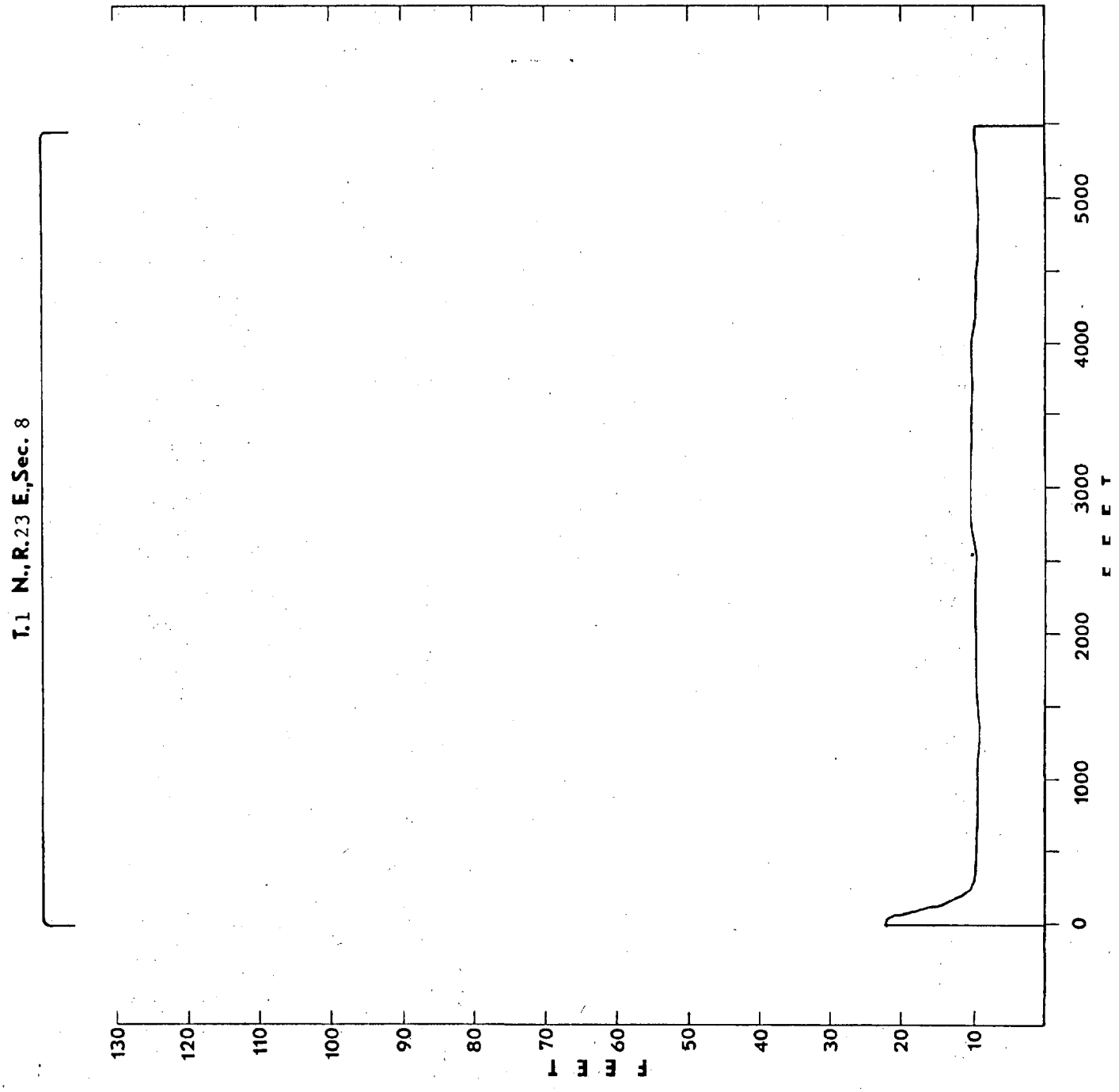


SAFETY FACTOR
- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL
- A-boreholes (high confidence)
- B-near boreholes stratigraphy visible
- C-no stratigraphy visible (low confidence)

1. BLUFF	a-area concealed by vegetation and revetment which are equal in height to the bluff, bluff height approximately 10 ft.		b-same conditions as in a-, sand dunes	
2. TOE	a-bedded dune and beach sands		b-concealed, toe covered by revetment total length of section	
3. BEACH	a-sand and some gravel accretion due to groin on point at beginning of section 17	b-no beach, new revetment(.31) all along here	c-50 to 100 ft. sand	d-essentially no beach; few areas between groins have some accumulation of sand and cobbles, but less than 5 ft.
4. PROFILES-none; the shoreline is concealed with protective structures throughout the entire section.				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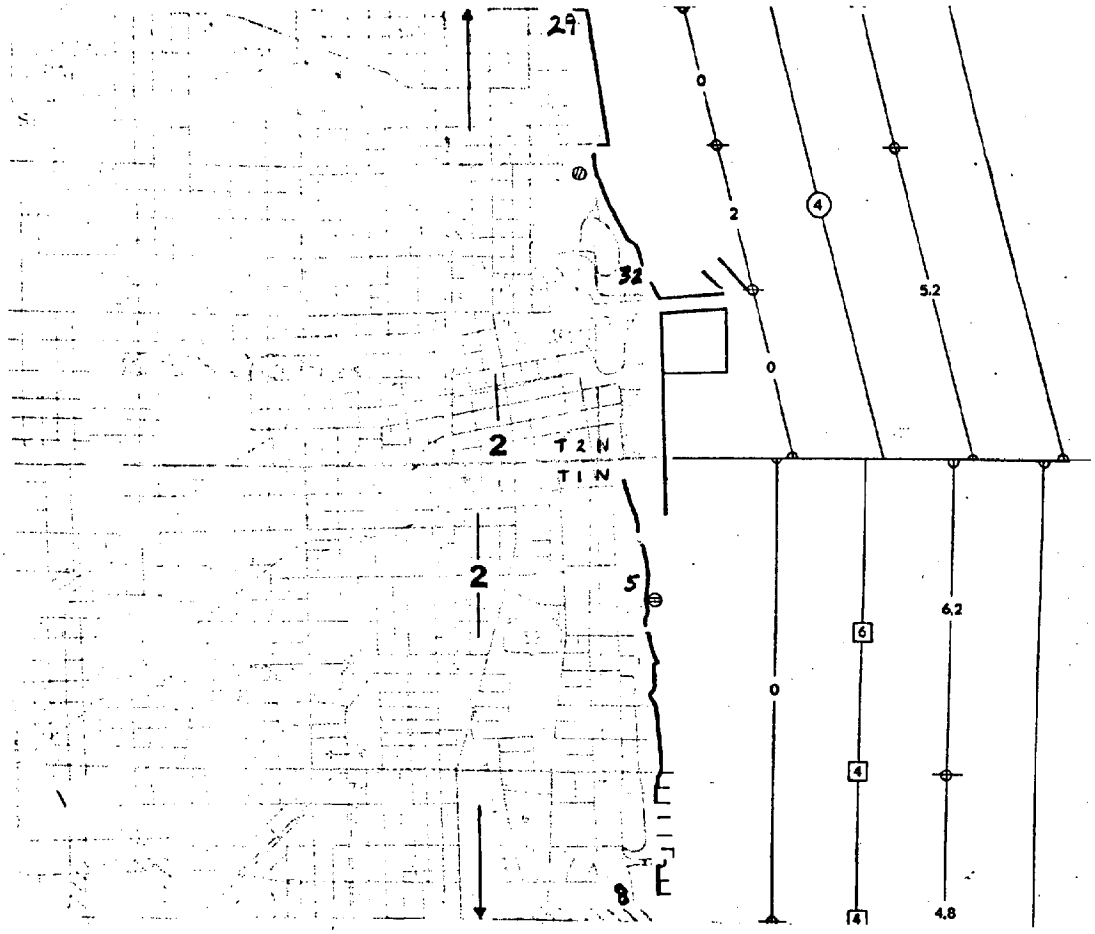
FEET

Reach 2

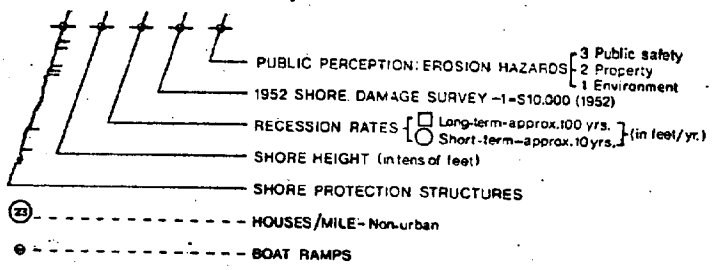
Reach 2, in Townships 1 and 2 North, Range 23 East, covers 3 miles of shoreline in central Kenosha County. It is virtually coextensive with the City of Kenosha, extending from the southern end of Southport Park in section 8 northward through the downtown and harbor area to the north end of Lake View (Kennedy) Park in section 30. The entire shoreline is protected with stone revetments and other structures, with the exception of short segments of public bathing beaches at Southport and Simmons Island Parks. For this reason and also because of the low rank accorded this reach — priority rank number 28 with a per mile value of 4, the only part examined systematically was a half-mile stretch of shoreline at Southport Park. Data on beach conditions and shore protection structures were also obtained at Eichelmann Park in section 5.

Except for the bathing beach area, where the beach is 50 to 100 feet wide, no beach is present in the Southport Park segment. The bluff is only 5 to 10 feet high, and both bluff and toe materials are everywhere concealed by a continuous stone revetment. Although materials are not exposed, the bluff is probably composed of sand. The segment is marked by a dozen additional structures, most of which are old groins that are today largely non-functional and in need of repair. Small areas of sand accumulation are found adjacent to one or two of these groins, but even here the beach is less than 5 feet wide.

The sand beach at Eichelmann Park, in the area where the coast is oriented northeast-southwest, broadens from 63 feet on the east to 83 feet on the west. It is protected from eastern and northeastern storm waves by a 650-foot long north-south stone breakwater. South of the beach, where the coast is oriented generally north-south, a 350-foot long poured concrete bulkhead protects the shore. No bluff is present. The graded slope behind the beach is artificial fill; the material behind the sea wall is mostly sand.


29
32
2
T 2 N
T I N
2
5
8
0
2
4
5.2
0
6
4
0
6.2
4
4.8

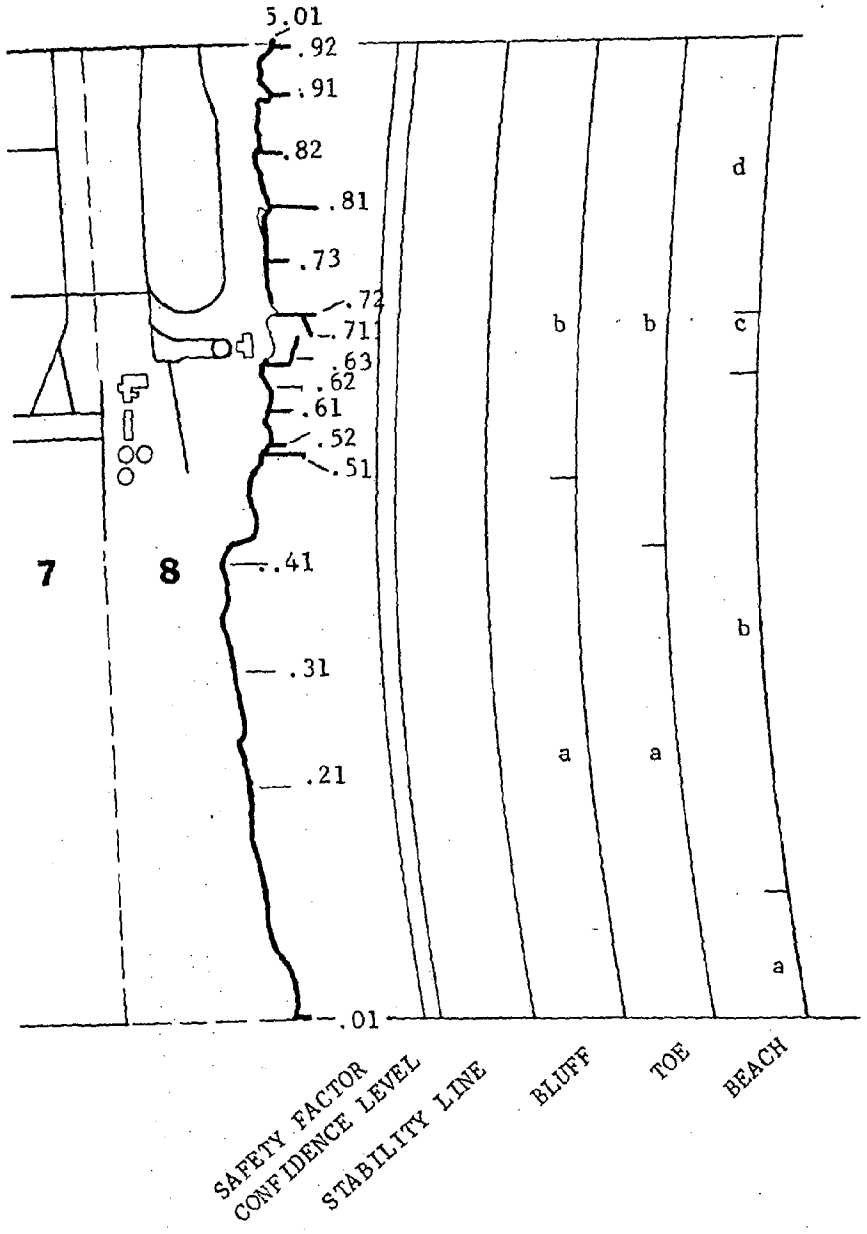
Reach 2


PUBLIC PERCEPTION: EROSION HAZARDS
3 Public safety
2 Property
1 Environment
1952 SHORE DAMAGE SURVEY –1=$10,000 (1952)
RECESSION RATES
Long-term-approx.100 yrs.
Short-term-approx.10 yrs.
(in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE–Non-urban
BOAT RAMPS


N


1 mile

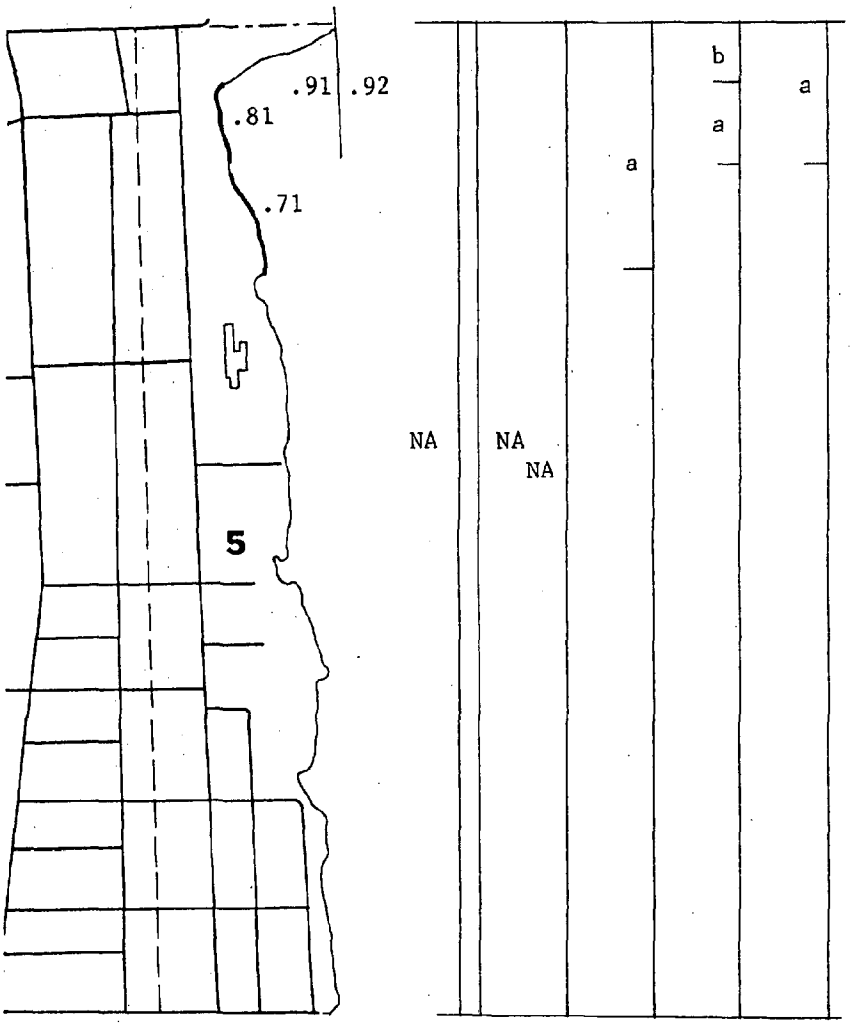
T.1N.,R.23E.,Sec.8



SAFETY FACTOR
- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL
- A-boreholes (high confidence)
- B-near boreholes stratigraphy visible
- C-no stratigraphy visible (low confidence)

1. BLUFF	a-area concealed by vegetation and revetment which are equal in height to the bluff, bluff height approximately 10 ft.		b-same conditions as in a-, sand dunes	
2. TOE	a-bedded dune and beach sands		b-concealed, toe covered by revetment total length of section	
3. BEACH	a-sand and some gravel accretion due to groin on point at beginning of section 17	b-no beach, new revetment (.31) all along here	c-50 to 100 ft. sand	d-essentially no beach; few areas between groins have some accumulation of sand and cobbles, but less than 5 ft.
4. PROFILES-none; the shoreline is concealed with protective structures throughout the entire section.				



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CONFIDENCE LEVEL
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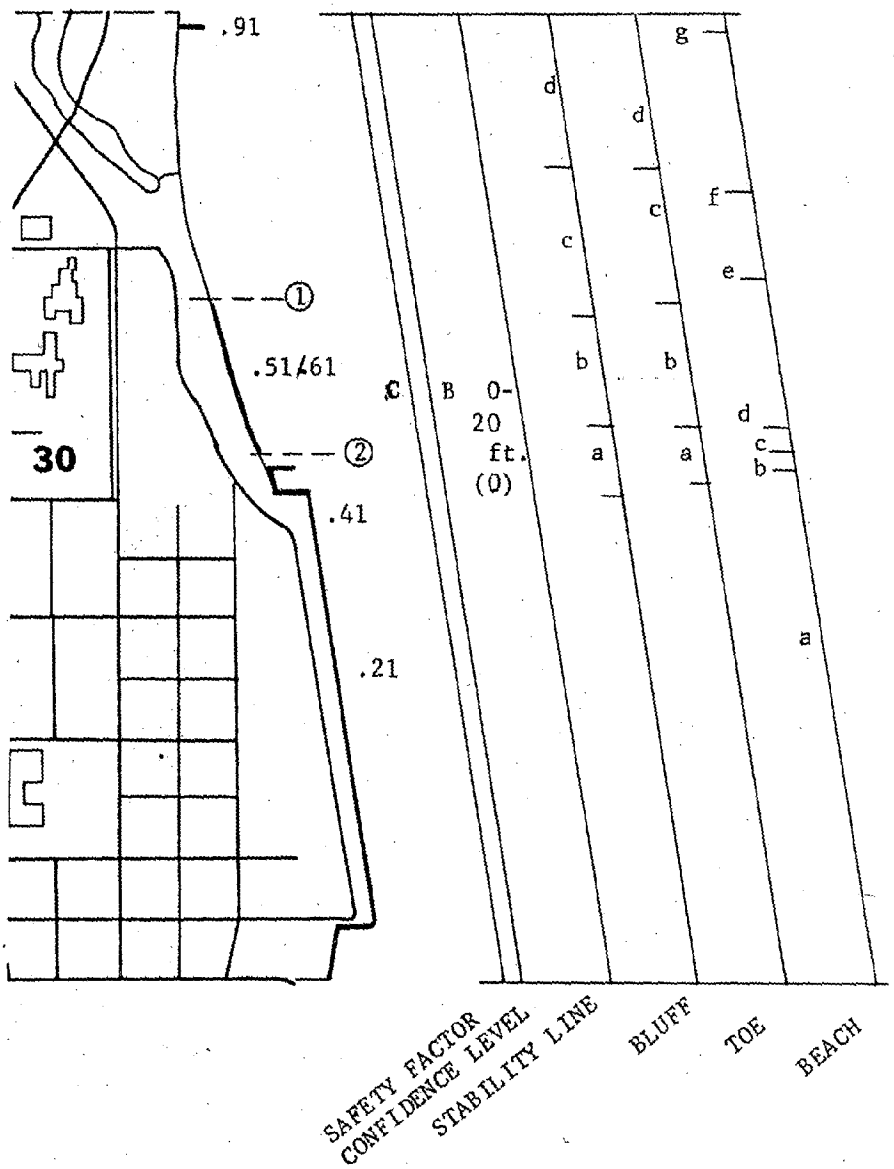
- C-no stratigraphy visible (low confidence)

1. BLUFF a-graded
   no bluff present

2. TOE a-sand b-artificial fill (in back of beach)

3. BEACH a-63-83 ft. sand, beach widens westward from 63-83 ft.



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- C-greater than 1.25

CONFIDENCE LEVEL
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- B-near boreholes stratigraphy visible
- C-no stratigraphy visible (low confidence)

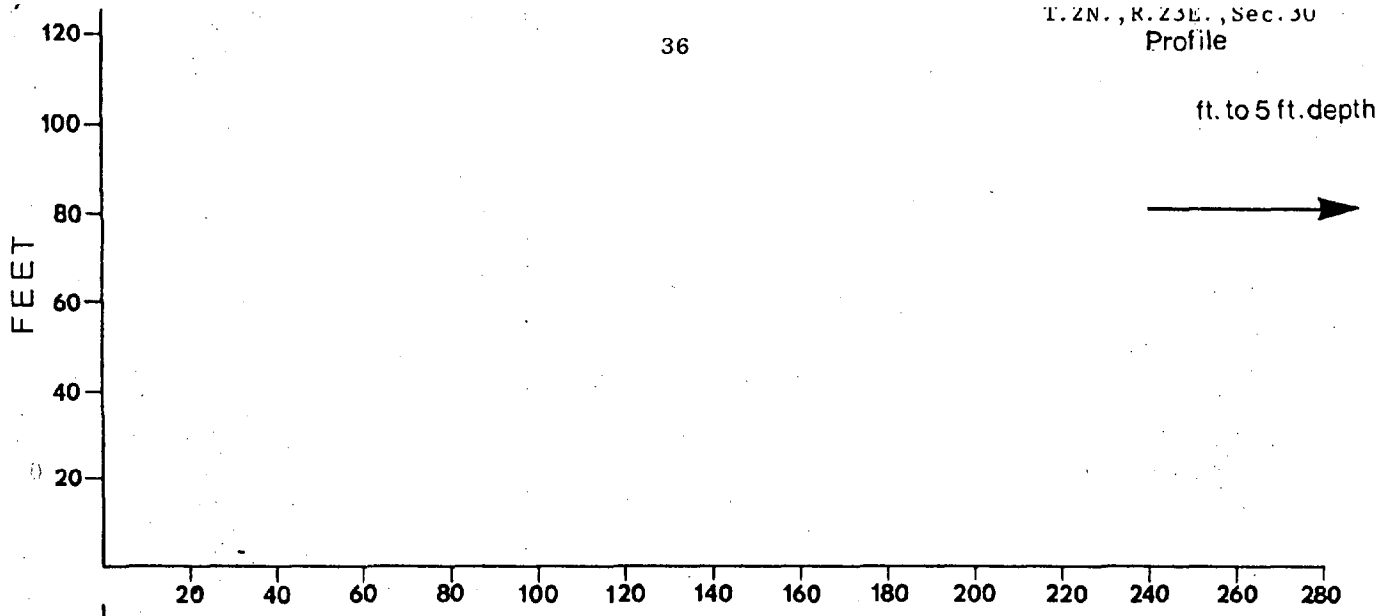
1. BLUFF	a- 5-10 ft. sand appears to be stabilized	b-this area has graded and gradual slopes;no bluff. -maximum height 2 ft.	c-16 ft. maximum height of bluff in this segment, mostly about 10 ft. sand, stable	d-no bluff, gradual slope; maximum height about 4-5 ft.	
2: TOE	a-sand,gravel and some artificial fill, mostly sand	b-no bluff	c-sand, some silt interbedded	d-no bluff	
3. BEACH	a-no beach	b-72 ft. south, beach narrows to 0ft.	c-85 ft. sand and gravel	d-170 ft. sand and gravel	e-125 ft. sand and gravel
	f-215 ft. sand and gravel	g-275 ft. sand and gravel			

*fragments and slabs of precast concrete scattered about on upper part of beach represent remains of old groins. Some slabs now being used as bases for picnic grills,however they are not in original position.

T.2N.,R.23E.,Sec.30

Profile

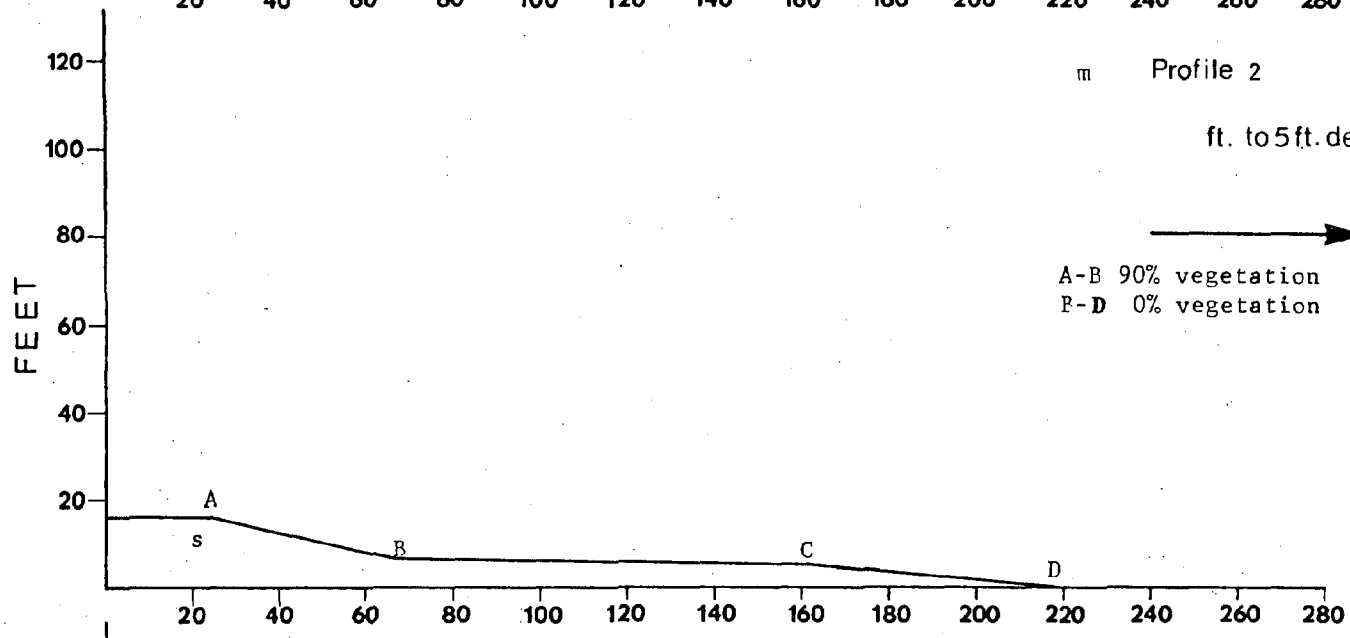
ft. to 5 ft. depth



Profile 2

ft. to 5 ft. depth

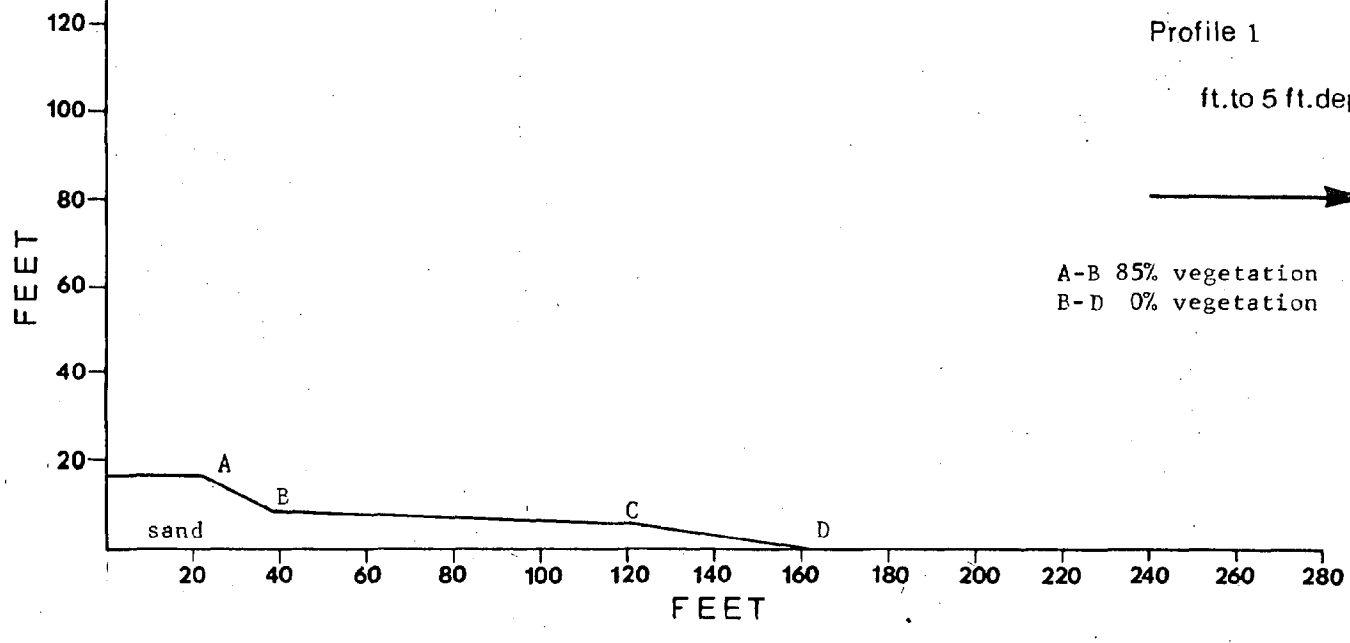
A-B 90% vegetation
B-D 0% vegetation

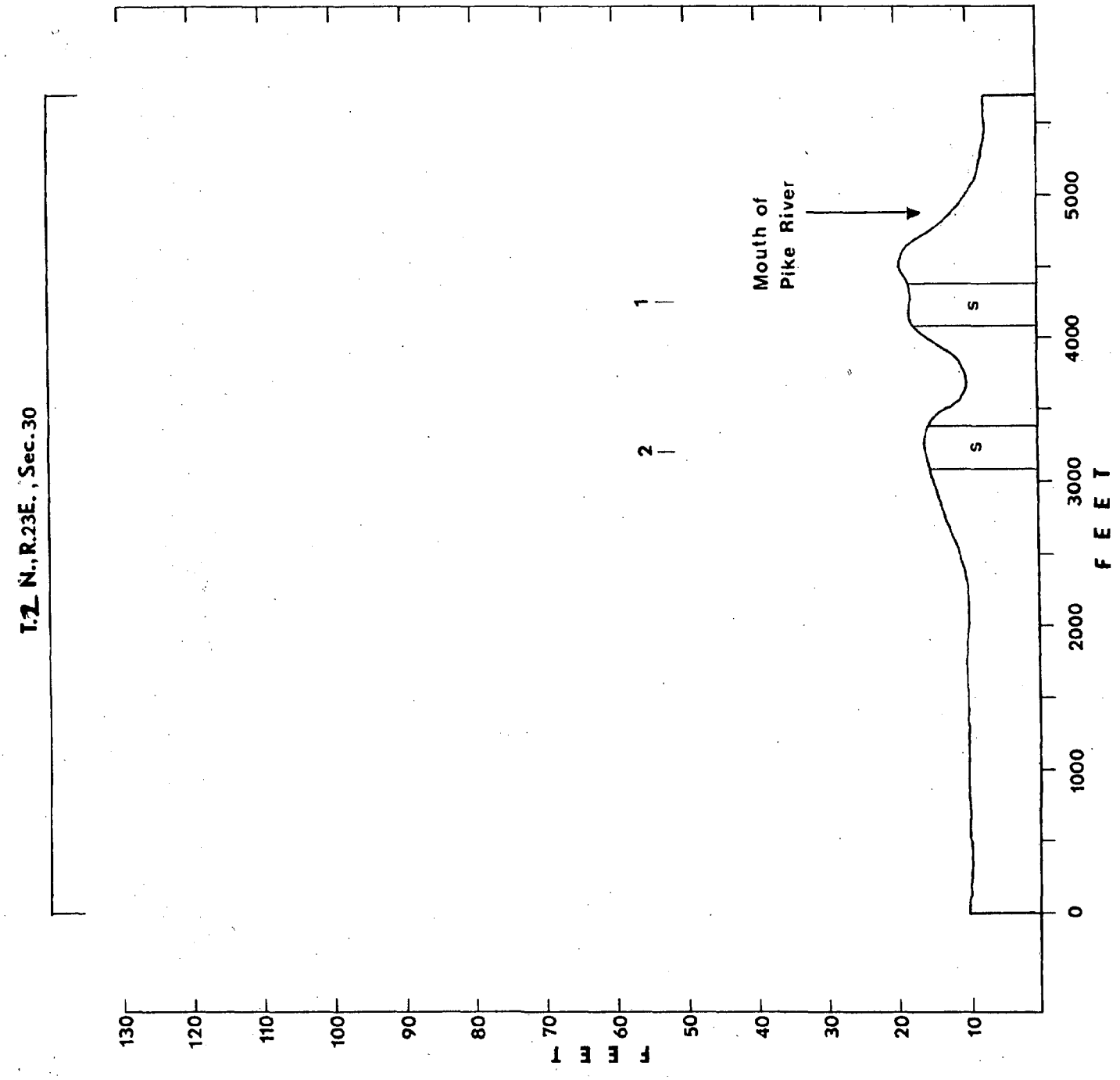


Profile 1

ft. to 5 ft. depth

A-B 85% vegetation
B-D 0% vegetation




T.2 N., R.23E., Sec.30
Mouth of
Pike River
1
2
S
S
0
1000
2000
3000
4000
5000
FEET
10
20
30
40
50
60
70
80
90
100
110
120
130
FEET

Reach 3

Erosion reach 3 of the Lake Michigan shoreline is located in northern Kenosha and southern Racine Counties, in Townships 2 and 3 North, Range 23 East. It is one of the longer reaches of the shoreline, having a grid length of exactly 6 miles and an actual shoreline distance of approximately 6½ miles. Geographically, the reach can be thought of as a suburban coastal corridor that connects the City of Kenosha on the south with the City of Racine on the north. Except for only three or four small areas, including the Town of Mount Pleasant fire station and park property in sections 28 and 29 near the north end, the entire northern three-fourths of the reach is subdivided; most of the lots are occupied by single-family residences, but a few are used for apartments and small businesses. Immediately to the south in sections 18 and 19 is the campus of Carthage College, which extends along the shoreline for a distance of more than one-half mile; the rest of the southern quarter is reserved for recreational use and is the site of Alford and Pennoyer Parks, which together are about 6,000 feet in length.

Reach 3 was ranked as the ninth most critical stretch of Wisconsin's Lake Michigan shoreline, with a per mile value of thirteen. In view of the considerable property damage and shoreline recession that is currently taking place throughout much of this reach, it would appear that the reach should be assigned a somewhat higher priority.

Beach conditions in this reach are extremely variable. Beach width, in particular, exhibits great variability, ranging from complete absence of a beach in many places to the presence of an extensive beach that exceeds 275 feet in width. The most marked change in conditions occurs in section 19 near the south end of the Carthage College campus, approximately 6,000 to 6,500 feet north of the southern boundary of the reach. North of here the beach generally ranges from 0 to 40 feet wide, the exact width at

any given locality being controlled in part by the presence or absence of shore protection structures. Because of the considerable variability and nearly continuous changes in width, it is virtually impossible to estimate an average beach width; a typical beach, however, would be about 10 to 15 feet wide. Beach materials consist of sand, pebbles, and some cobbles. South of Carthage College, in the Alford and Pennoyer Park areas, the beach widens appreciably. Nowhere is it less than 100 feet wide, except at the very southern end of the reach in section 30, where it rapidly narrows to zero. Typically, it is between 100 and 200 feet in width, and in one area it is nearly 300 feet across. The beach materials are mostly sand, with relatively lower amounts of gravelly components than farther north.

Much of this wide beach is attributable to the presence of a low, broad beach ridge, which is most distinct in northern Alford Park, pinching out just south of the new (July 1976) dolomite block revetment at the south end of the Carthage campus. The crest of this ridge ranges from 3 to 5 feet above lake level and is generally between 30 and 50 feet from the shoreline; the beach slope is typically 6 or 7 degrees (see profiles 2, 3, and 4, section 19). West of the crest the ridge drops as much as 6 or 7 feet to the toe of the bluff, which in some places therefore is 2-3 feet below present lake level. The backslope of the beach ridge nearly everywhere is more than 100 feet wide, with a slope of 2-5 degrees. Thus, the ridge is paralleled by a linear swale, which is partially filled with water and which supports a marsh-type vegetation.

Bluff conditions in this reach are also variable, but unlike beach conditions the changes are more regular or systematic. Although in any given sector of the shoreline the height of the bluff appears to be fairly uniform, bluff height gradually descends from north to south; in the northern part of the reach the bluff is nearly 40 feet high (see profile 4, section 29),

but at the south end it is generally 10 feet or less in height (see profiles 1 and 2, section 30). Whereas the bluff is virtually continuous throughout most of the reach, in the southernmost mile it is distinctly discontinuous, as a result of the upland surface near the shoreline having been narrowed and in places completely removed by normal erosional processes near the mouth of the Pike River.

Bluff and toe materials in this reach also exhibit a systematic change from north to south. In the upper part of the reach the lower two-thirds to three-fourths of the bluff is composed of calcareous silty clay till. The till is overlain by interbedded fine sands, silts, and clays of lacustrine origin (see profile 4, section 29; profile 1, section 32; and profiles 1 and 2, section 5). At two localities in the southern part of Racine County a second unit of silty clay till, about 5 feet thick, was observed to rest on the lacustrine sediments near the top of the bluff (see profile 3, section 32). The significance of this upper till and its true relationship to the lower till unit are presently unknown; very probably, however, it is a tongue extending laterally into the lacustrine sediments from the upper part of the main till body.

Nearly one mile south of the Racine-Kenosha County line the lacustrine/till contact descends to lake level, with a corresponding thickening of the lacustrine sediments (see profile 3, section 5), and thence disappears below lake level to the south. Still farther south, some of the lacustrine deposits tend to become more massive in character and also finer grained. A power auger hole drilled at the site of profile 4 in section 18 indicated that the lacustrine/till contact here occurs at a depth of about 20 feet below lake level. TP The bluff is everywhere capped by fine to coarse-grained sand deposits, which were probably deposited in a beach environment. At the southern end of the reach, however, the low bluff appears to be composed

almost entirely of sand, suggesting that the contact between the sand and the underlying lacustrine sediments has also dipped below modern lake level.

Shoreline protection structures are very abundant in the northern three-fourths of Reach 3. Approximately 180 individual structures were identified and described in the 5-mile segment of shoreline that lies north of Carthage College. These structures consist of a great variety of both shore-parallel and shore-normal devices, as well as earthen and man-made materials used for fill. The Carthage campus is protected by a continuous dolomite rip-rap revetment. South of here, in Alford and Pennoyer Parks, modern shore protection structures are absent, the only structures being a series of 40-year old semi-permeable groins that have been largely destroyed or buried beneath the broad accretional beach deposits described above.

Remnants of four groins were found within a distance of 500 feet in the wooded area between the south edge of the Carthage campus and the unpaved parking triangle in Alford Park. Only partial concrete foundations of the upper ends of these structures, where they were tied to the toe of the bluff about 150 feet from the present shoreline, are still in place. The upper surface of a fifth groin, made of precast concrete, is present about 800 feet south of this group, about half-way between the shoreline and Sheridan Road. The structure was discovered by probing through the sand; however, the sand cover was removed from only a small area, and thus neither the maximum depth of sand nor the length of the structure that is buried beneath beach deposits are known.

A sixth old groin, also made of precast concrete, can be seen at the shoreline 500 feet farther south, opposite the north end of the paved parking lot. About 10 feet of the structure is present on the exposed beach, with the eastern end extending well out into the water. The known length of the groin is approximately 220 feet, but most of it is buried by an accumulation

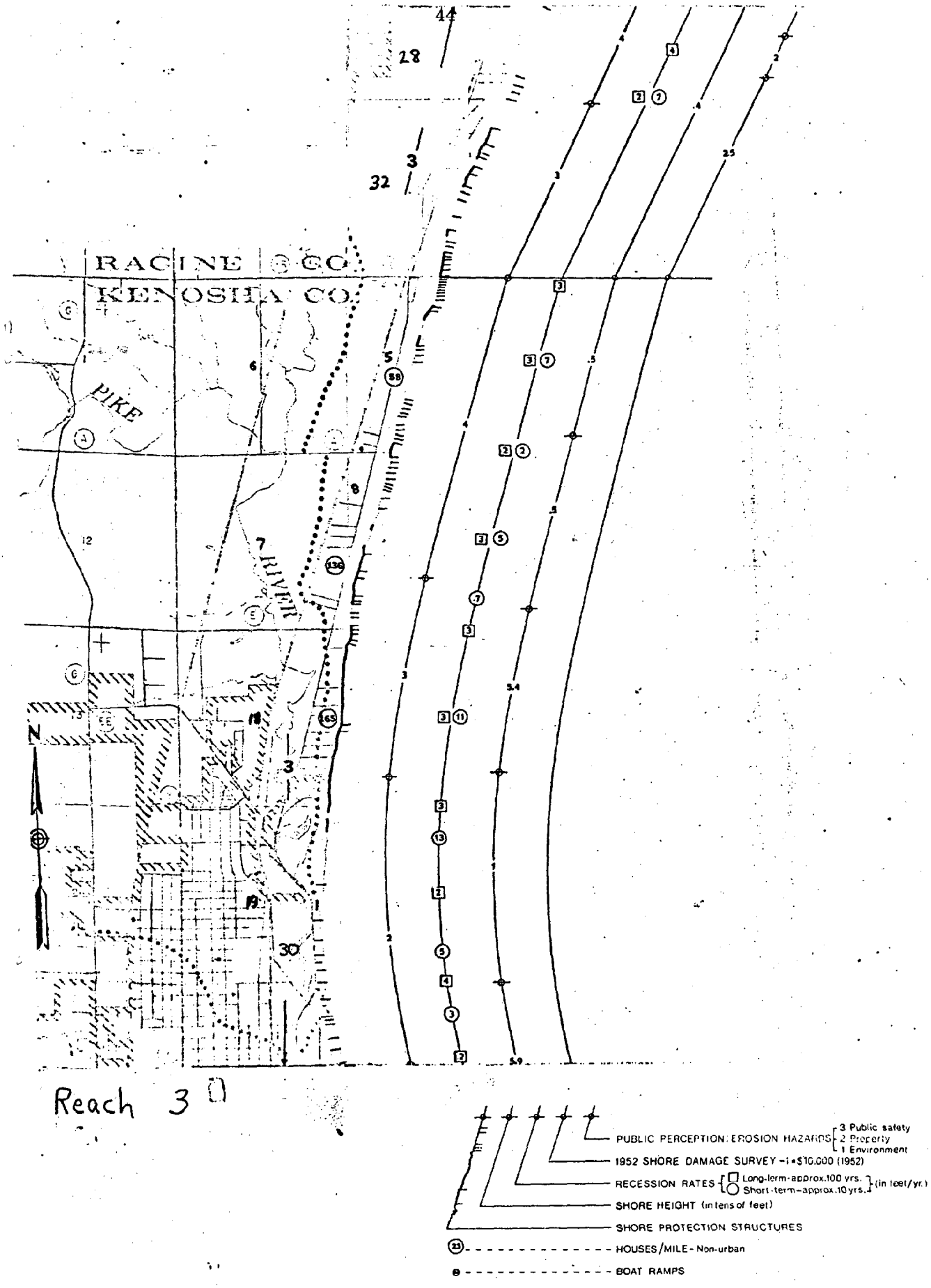
of sand in the form of a low beach ridge. The maximum thickness of the sand cover is estimated to be nearly 4 feet. The surface of the groin is also visible on the backslope of the beach ridge, 160 or 170 feet from the shoreline. The foundation of the structure was excavated from here to its upper end near the toe of the bluff below the parking area, where it is buried by 3 feet of sand and gravel.

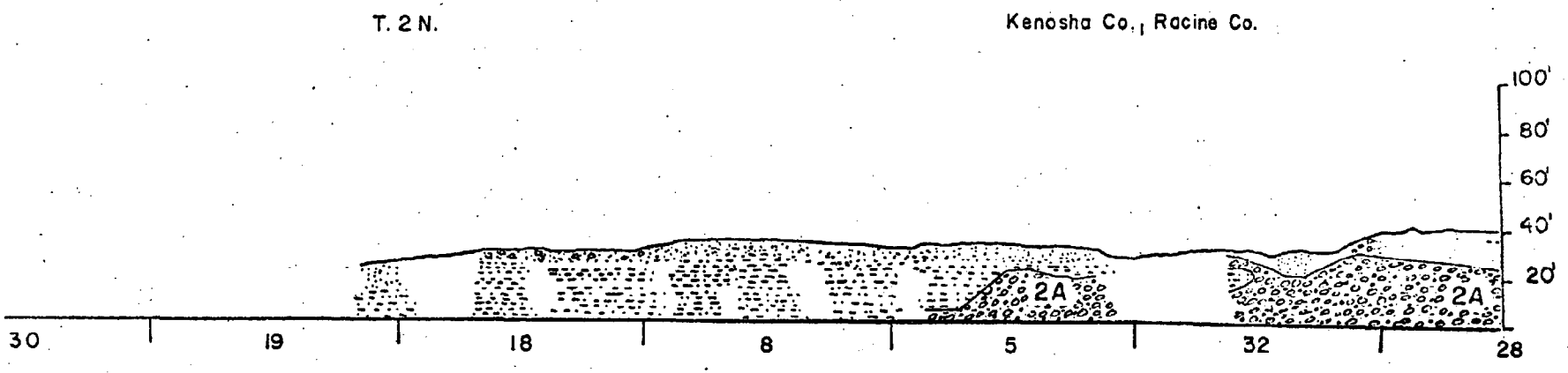
Still another groin, of similar design and material is present still farther south, near the north end of section 30. About 45-50 feet of this structure is visible at the shoreline, partly above and partly below lake level. Like the groin to the north, the structure passes beneath accretionary beach deposits estimated to be about 4 feet thick. This groin could not be found on the backslope of the beach ridge, but two large slabs of precast concrete similar in design to those in the groin at the shoreline very probably came from the same structure. Although not in place, they apparently are not far removed from their original position.

Fragments and slabs of old groins are scattered about the upper part of the beach in Pennoyer Park. Some are currently being used as bases for picnic grills. The remains of only one structure appear to be in place; at the south end of the park part of a groin can be seen beneath the newly constructed dolomite block revetment that extends southward along the shoreline of Lake View Park.

The evidence afforded by the extensive beach in sections 19 and 30, a beach that is 100 to 300 feet wide and more than $1\frac{1}{4}$ miles long, and by these old groins, buried in places by at least 4 feet of sand, is both convincing and conclusive: the southern part of Reach 3 in Alford and Pennoyer Parks has been a zone of major beach accretion for some time, possibly for several decades.

Except for the Alford and Pennoyer Park areas, shoreline recession and slope failure are serious problems throughout the entire reach. Some houses have, in fact, collapsed during the course of the present study and many additional homes situated near the bluff edge are in danger of being destroyed within the near future. Toe erosion by wave action, gully cutting by small streams and by stormwater drainage spilling over the bluff, rotational and planar motion of small to moderate size slump blocks at the bluff edge, sapping and undercutting within the bluff caused by water issuing from the more permeable layers — especially at the contacts between layers of differing permeability within the lacustrine sequence, and mudflows in the clay-rich till and fine-grained lacustrine sediments are all active mechanisms of slope failure in this reach. All profiles for Reach 3 north of the beach accretion area in Alford Park illustrate one or more of these conditions.


RACINE CO.
KENOSHA CO.
PIKE
7 RIVER
N
Reach 3
PUBLIC PERCEPTION: EROSION HAZARDS { 3 Public safety, 2 Property, 1 Environment
1952 SHORE DAMAGE SURVEY - 1 = $10,000 (1952)
RECESSION RATES { Long-term-approx.100 yrs., Short-term-approx.10 yrs. } (in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE - Non-urban
BOAT RAMPS



LEGEND

SAND
SILT
COVERED OR INACCESSIBLE
GRAVEL
CLAY
TILL
SAND AND GRAVEL
CLAYEY SILT, SILTY CLAY
MIXED SEDIMENTS

Generalized longitudinal section showing bluff stratigraphy in Reach 3. Numbers along base of diagram are geographic (1 mile) sections.

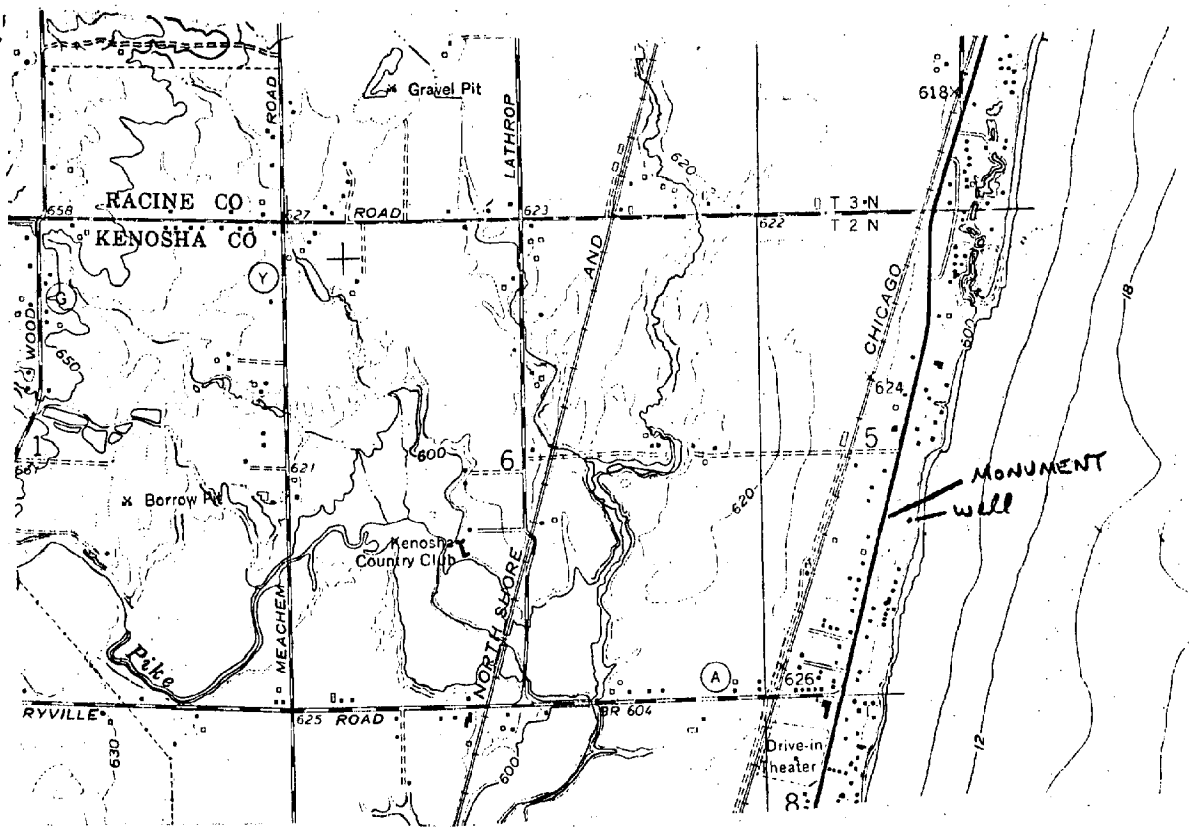
University of Wisconsin--Extension
Geological and Natural History Survey
1815 University Avenue, Madison, Wisconsin 53703

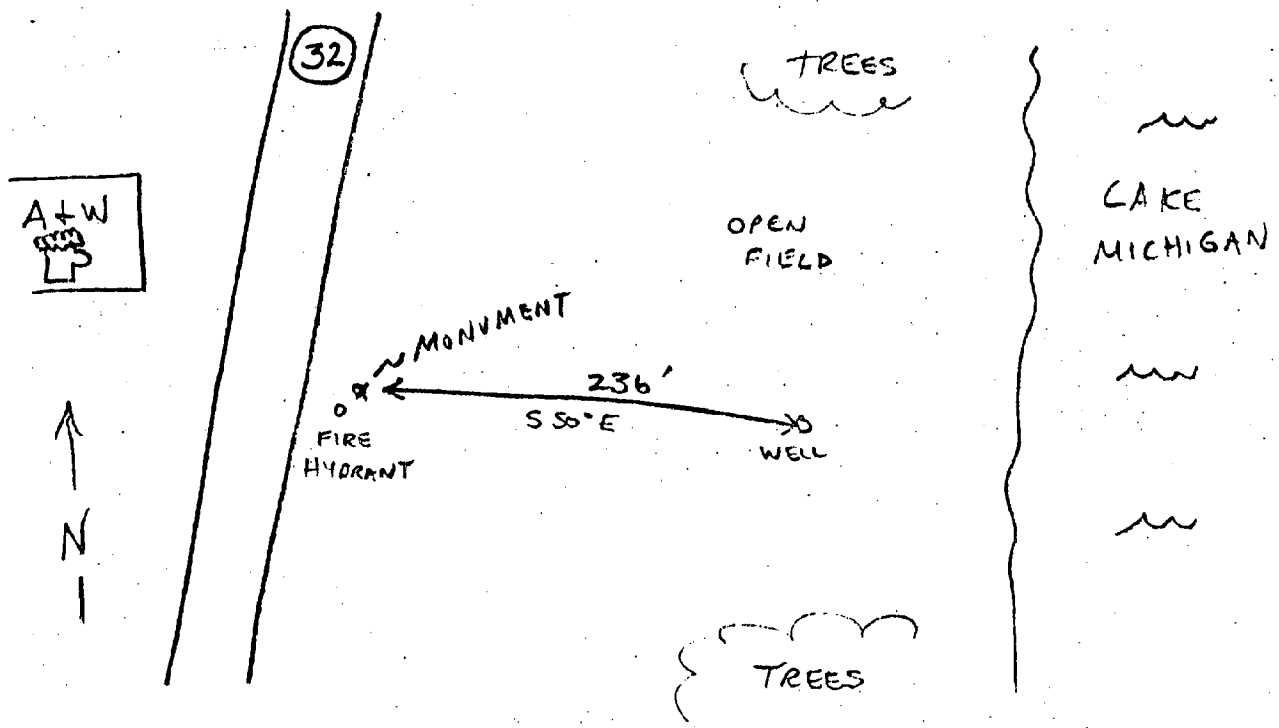
LOCATION AND MONUMENTATION SKETCHES

Boring No. GT-9, Racine South Quad., ~~Racine Co.~~ KENOSHA Co.
center / west ½ / sec. 5 / T. 2N. / R. 23 E.

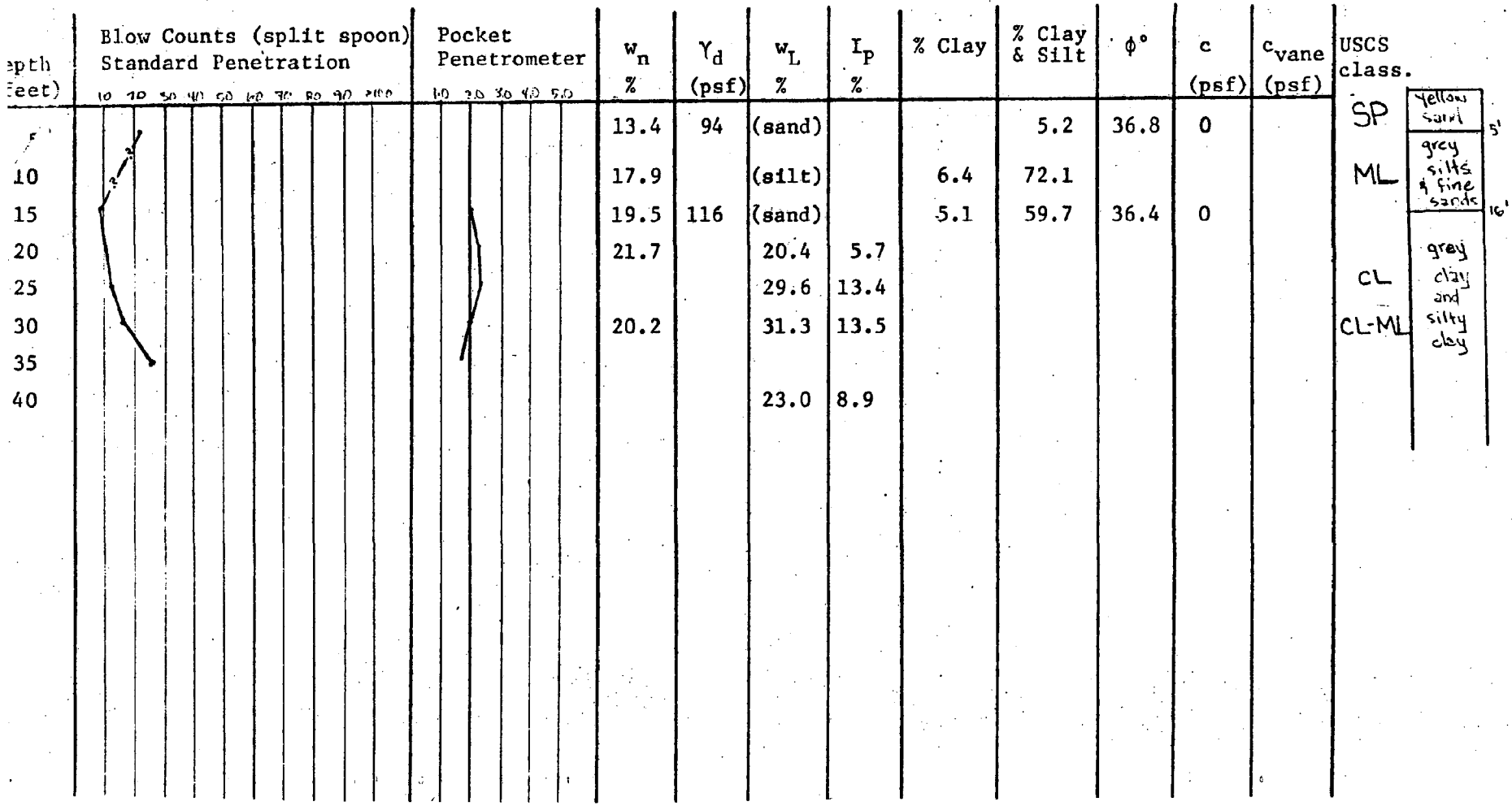
Date

Draw





Borehole: GT-9 Location: Kenosha County, Sec. 5, T2N



Depth (Feet)	w_n %	γ_d (psf)	w_L %	I_P %	% Clay	% Clay & Silt	$\phi°$	c (psf)	c_{vane} (psf)	USCS class.
5	13.4	94	(sand)			5.2	36.8	0		SP
10	17.9		(silt)		6.4	72.1				ML
15	19.5	116	(sand)		5.1	59.7	36.4	0		
20	21.7		20.4	5.7						CL
25			29.6	13.4						
30	20.2		31.3	13.5						CL-ML
35										
40			23.0	8.9						

yellow sand 5'
grey silts & fine sands 16'
grey clay and silty clay

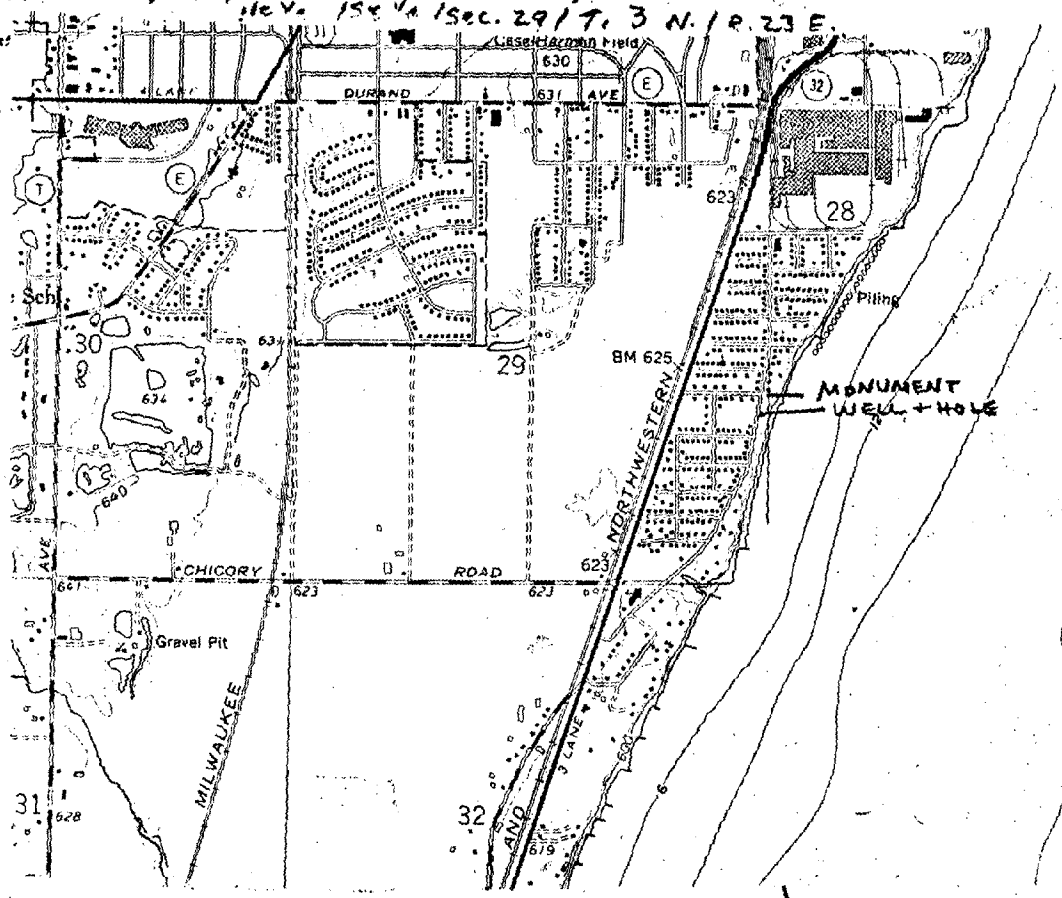
University of Wisconsin--Extension
Geological and Natural History Survey
1815 University Avenue, Madison, Wisconsin 53703

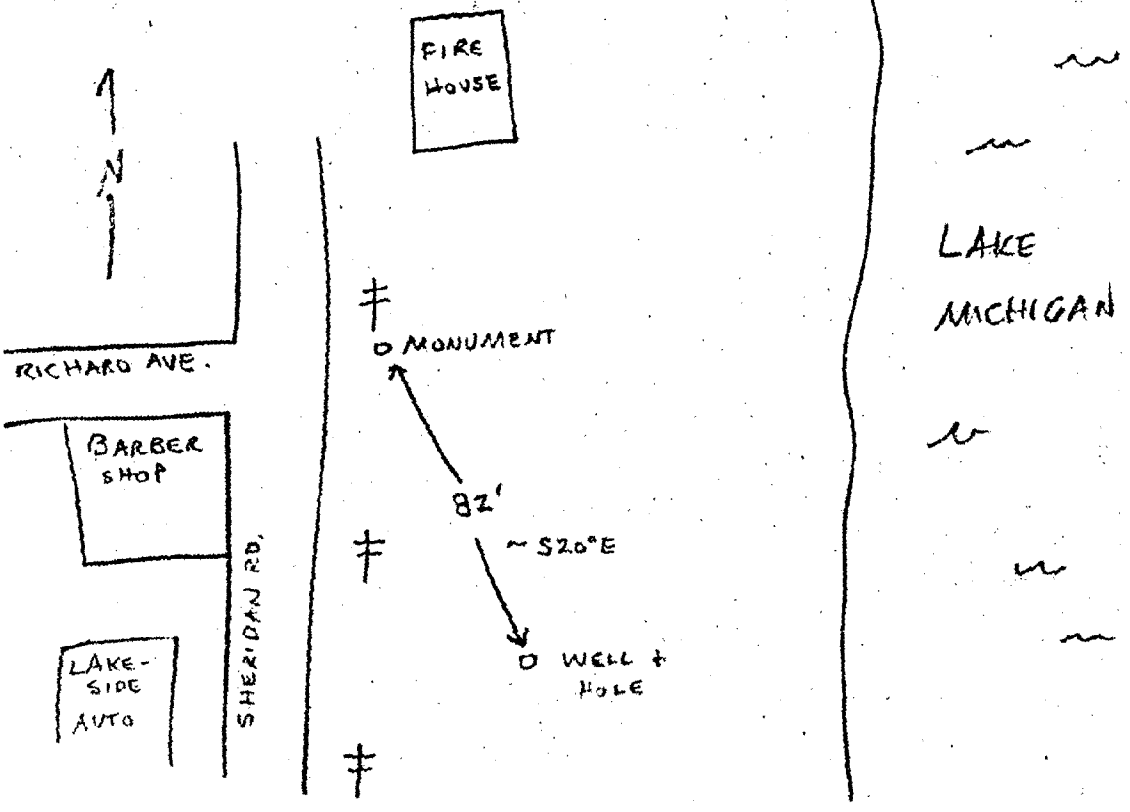
LOCATION AND MONUMENTATION SKETCHES

Boring No. GT-910, Racine South Quad., Racine Co.
NE¼ SE¼ Sec. 29, T. 3 N., R. 23 E.

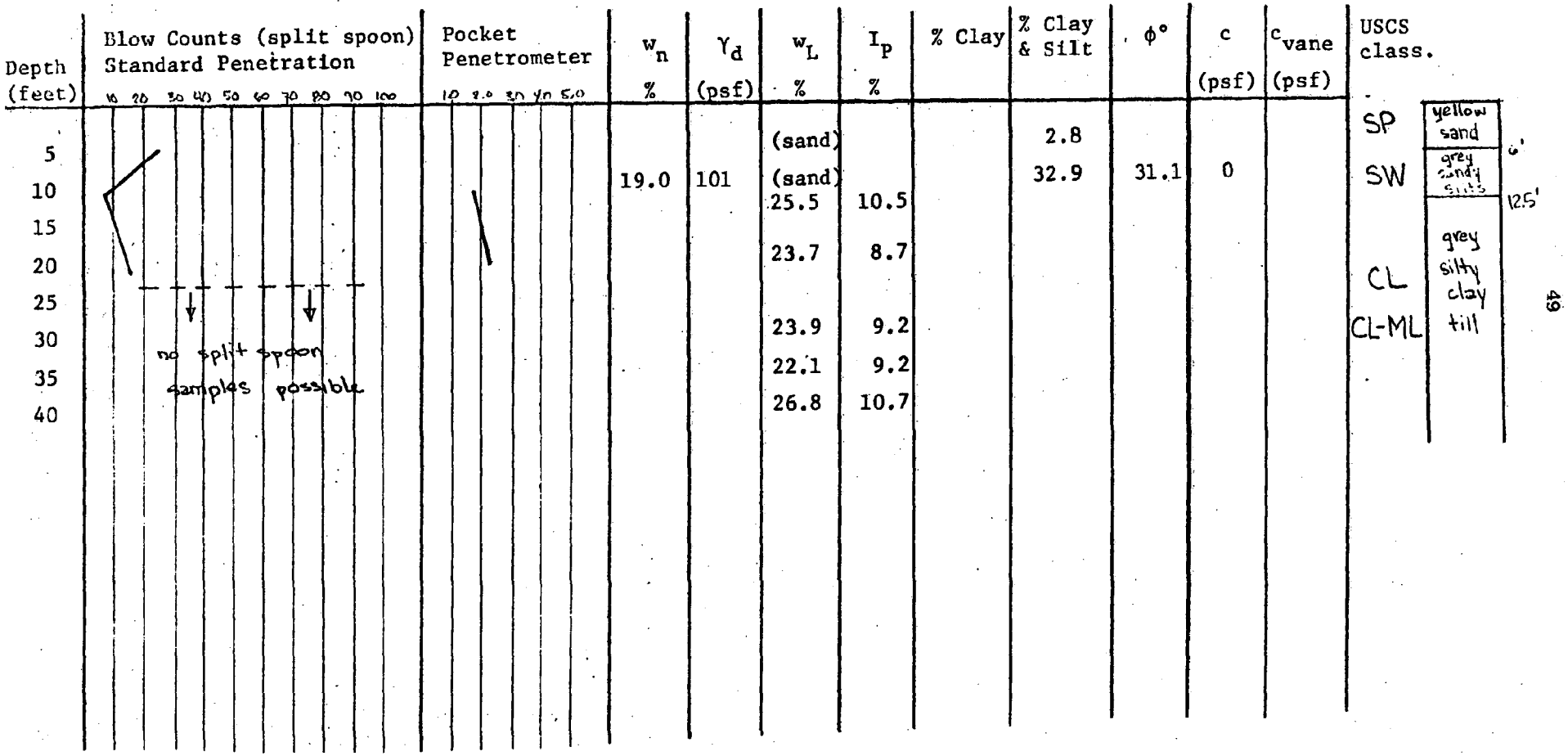
Date

Drawn by

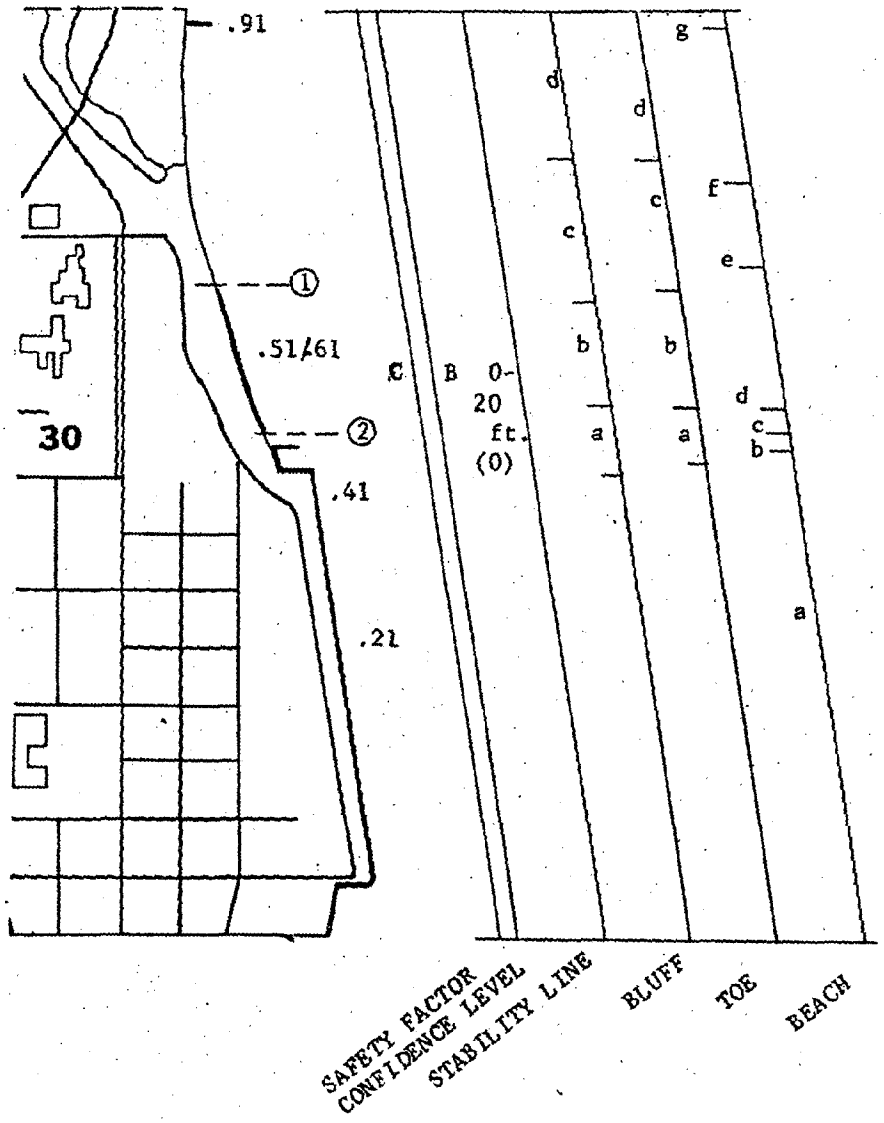




Borehole: GT-10 Location: So. Racine, Racine County, Sec. 29, T3N



T.2N.,R.23E.,Sec.30



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2: TOE	a-sand,gravel and some artificial fill, mostly sand	b-no bluff	c-sand, some silt interbedded	d-no bluff	
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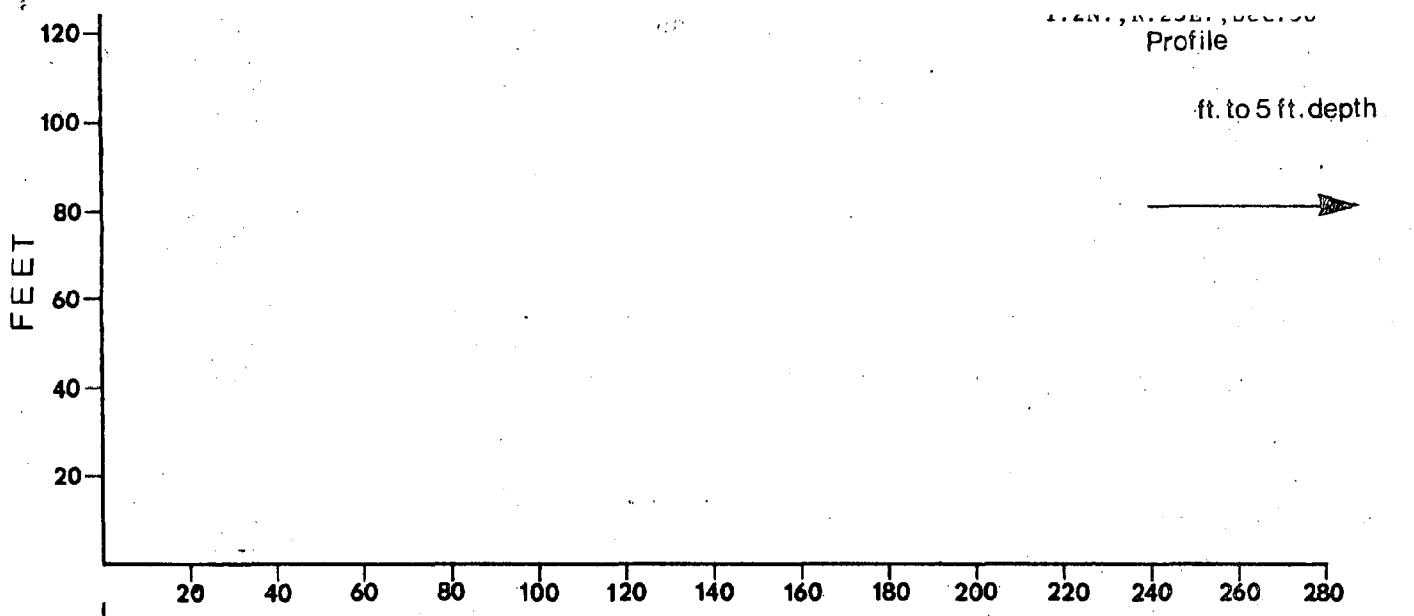
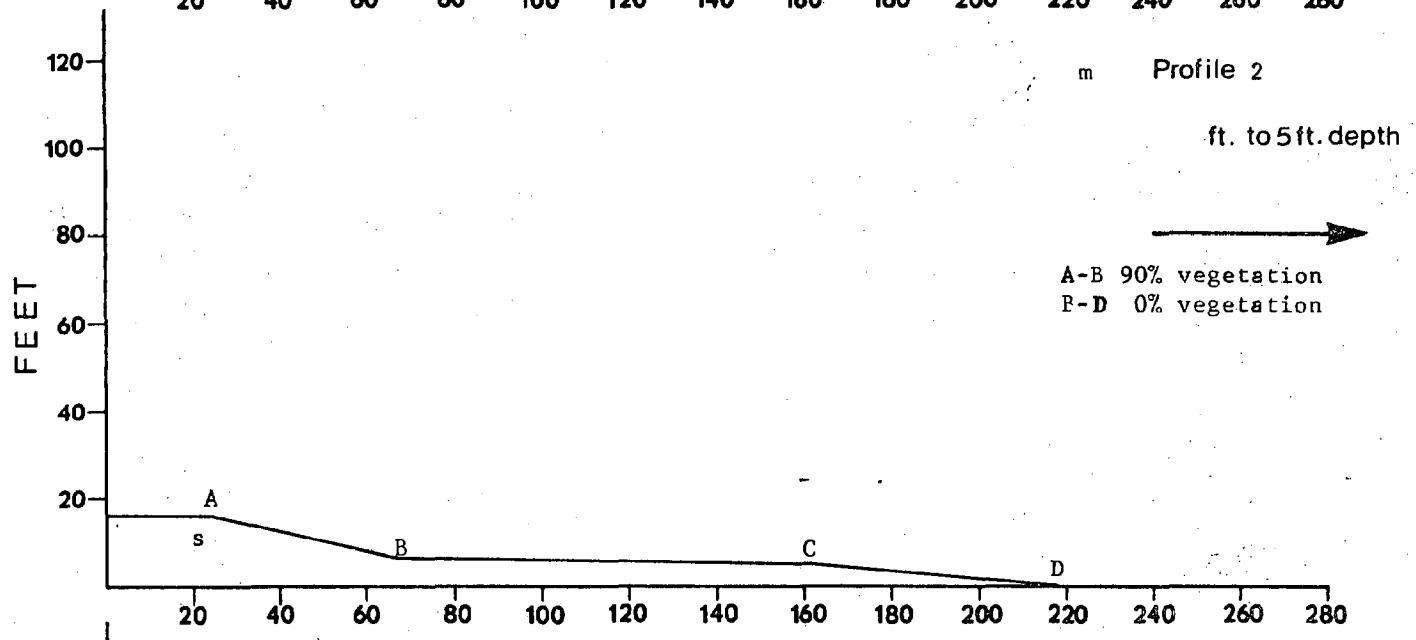
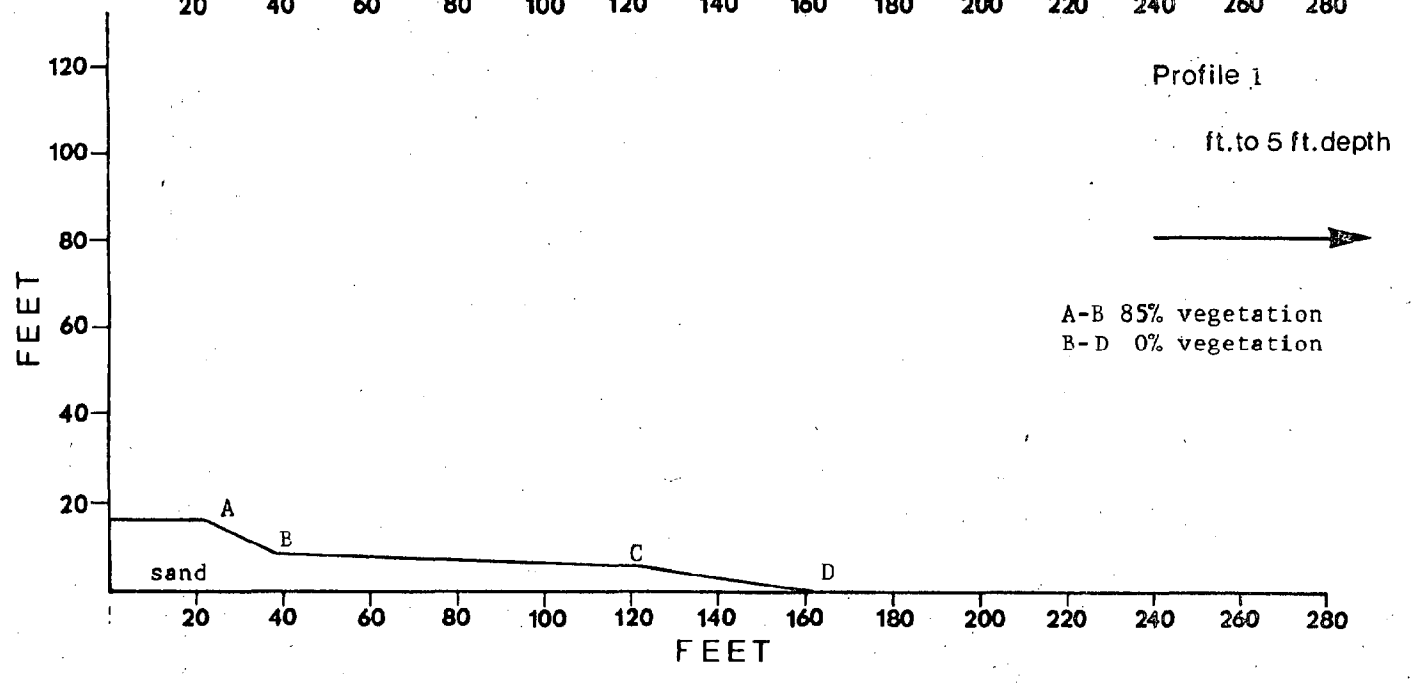
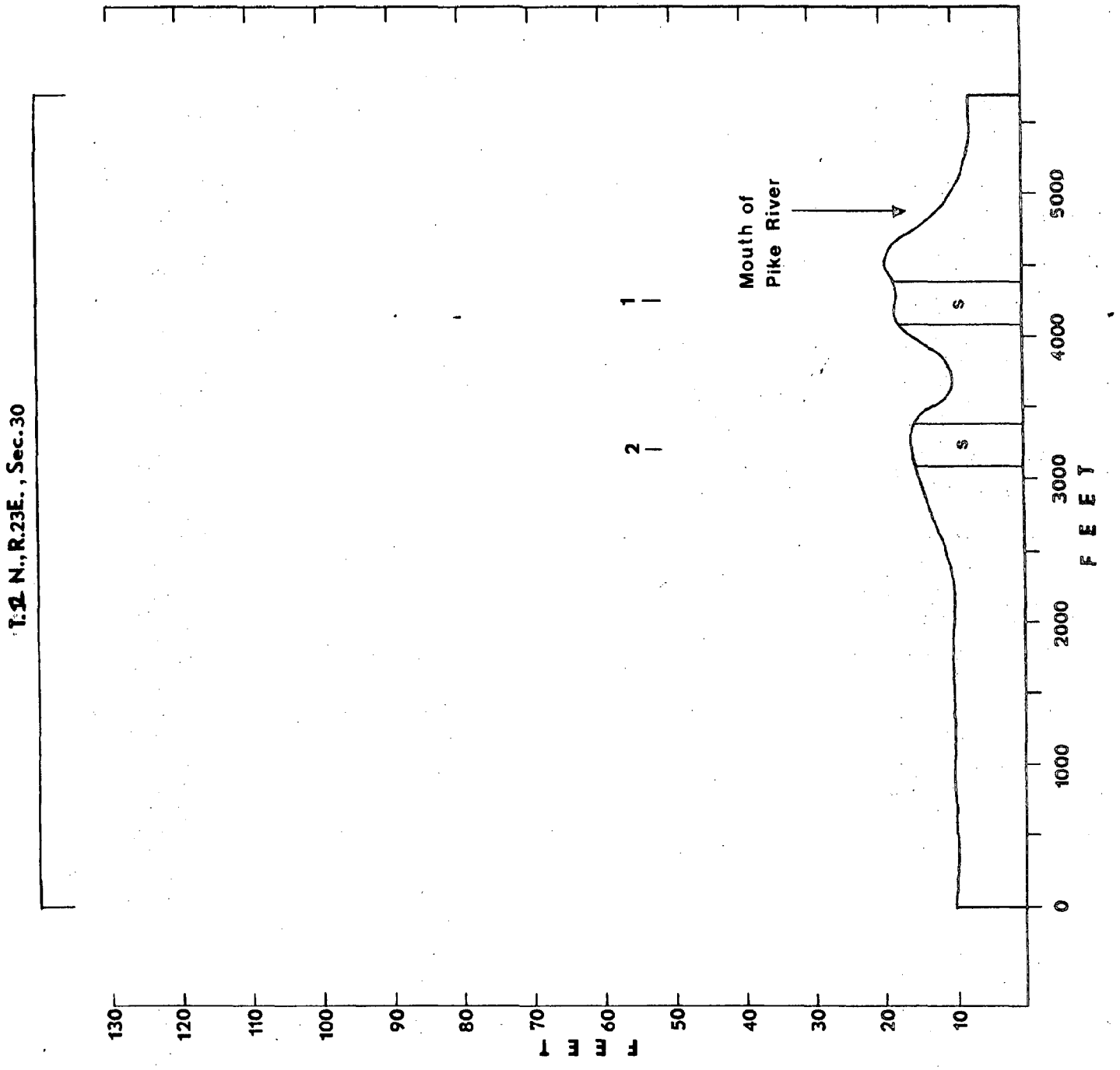
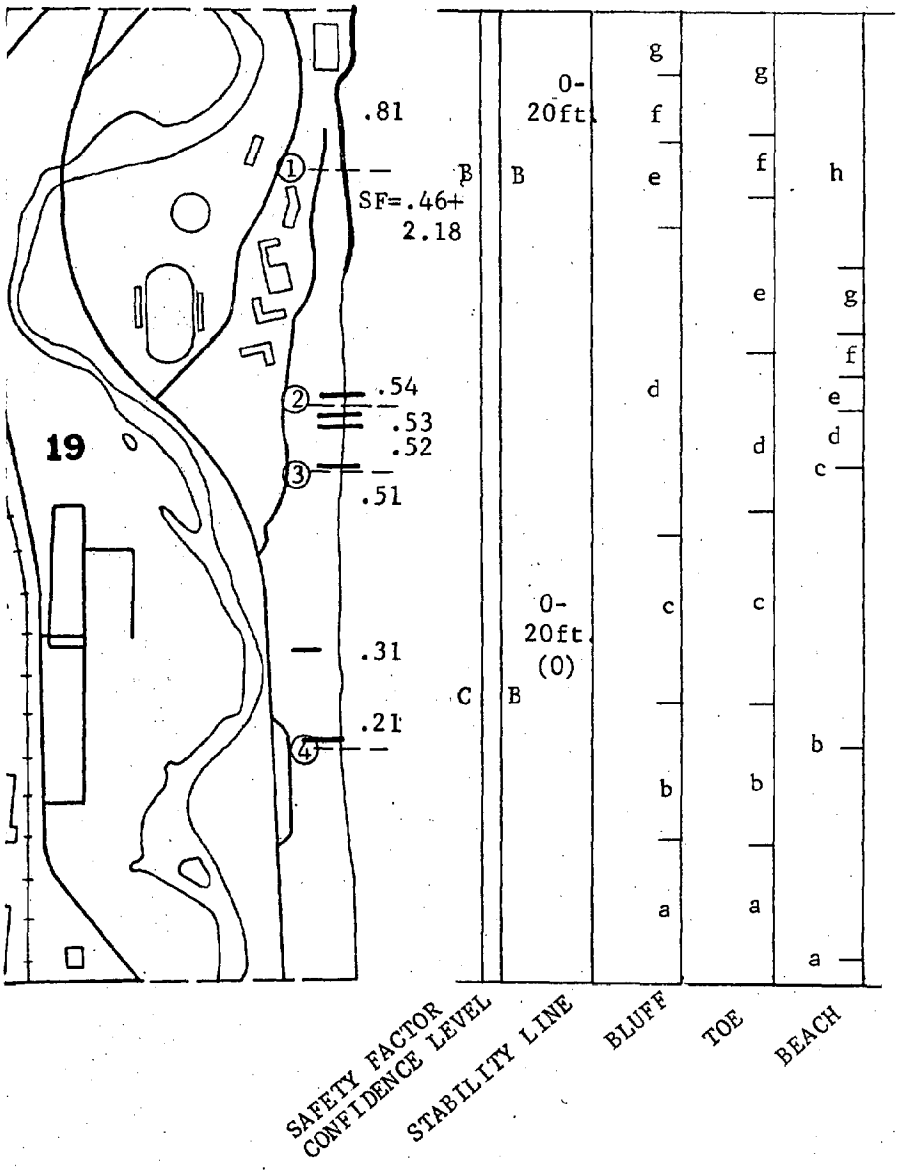

Profile
ft. to 5 ft. depth
FEET
120
100
80
60
40
20
20 40 60 80 100 120 140 160 180 200 220 240 260 280


m
Profile 2
ft. to 5 ft. depth
A-B 90% vegetation
B-D 0% vegetation
FEET
120
100
80
60
40
20
A
s
B
C
D
20 40 60 80 100 120 140 160 180 200 220 240 260 280


Profile 1
ft. to 5 ft. depth
A-B 85% vegetation
B-D 0% vegetation
FEET
120
100
80
60
40
20
A
B
C
D
sand
20 40 60 80 100 120 140 160 180 200 220 240 260 280
FEET


T.21 N., R.23E., Sec.30
Mouth of
Pike River
1
2
S
S
FEET
0
1000
2000
3000
4000
5000
FEET
10
20
30
40
50
60
70
80
90
100
110
120
130



SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

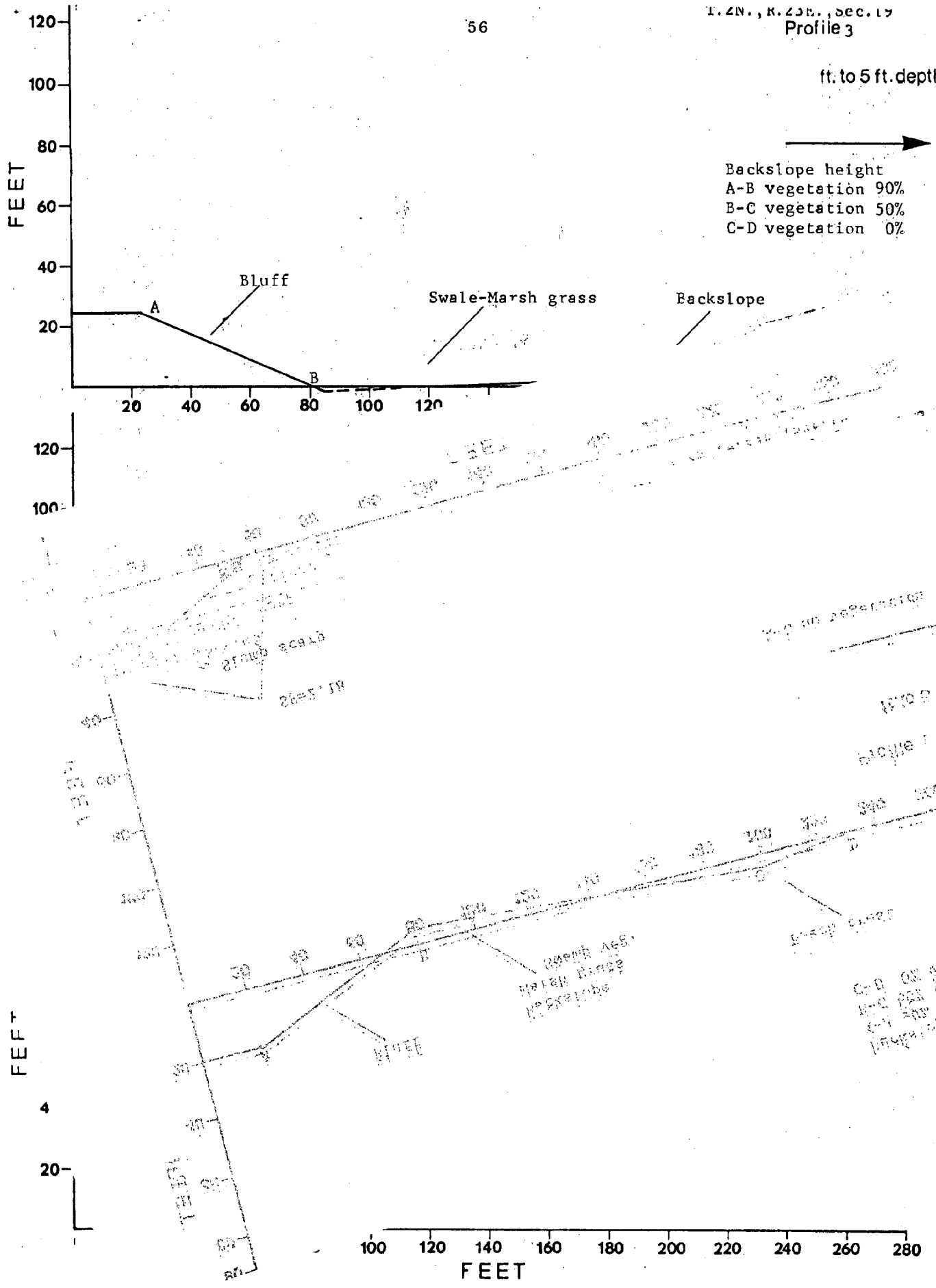
1.BLUFF	a-no bluff gentle slope upward	b-grassed; reasonably stable	c-no bluff	d-stable; well vegetated, materials concealed	e-slump area, bluff partially graded
	f-relatively stable in most places; vegetated, bluff partially graded	g-no bluff; graded slope for building			
2. TOE	a-no bluff	b-sand	c-no bluff	d-sand and coarse silt	e-mostly covered
	f-pinkish brown lacustrine clay	g-concealed			
3. BEACH	a-275 ft. sand and some gravel	b-188 ft. sand, some gravel	c-194 ft. sand, some gravel	d-151 ft. sand and gravel	e-140 ft. sand and some gravel
	f-110 ft. sand and some gravel	g-20-100 ft. sand and gravel	h-no beach; beach concealed by new dolomite revetment now under construction		

4. STRUCTURES 282-b see map supplement for description

T.2N., R.23E., Sec.19

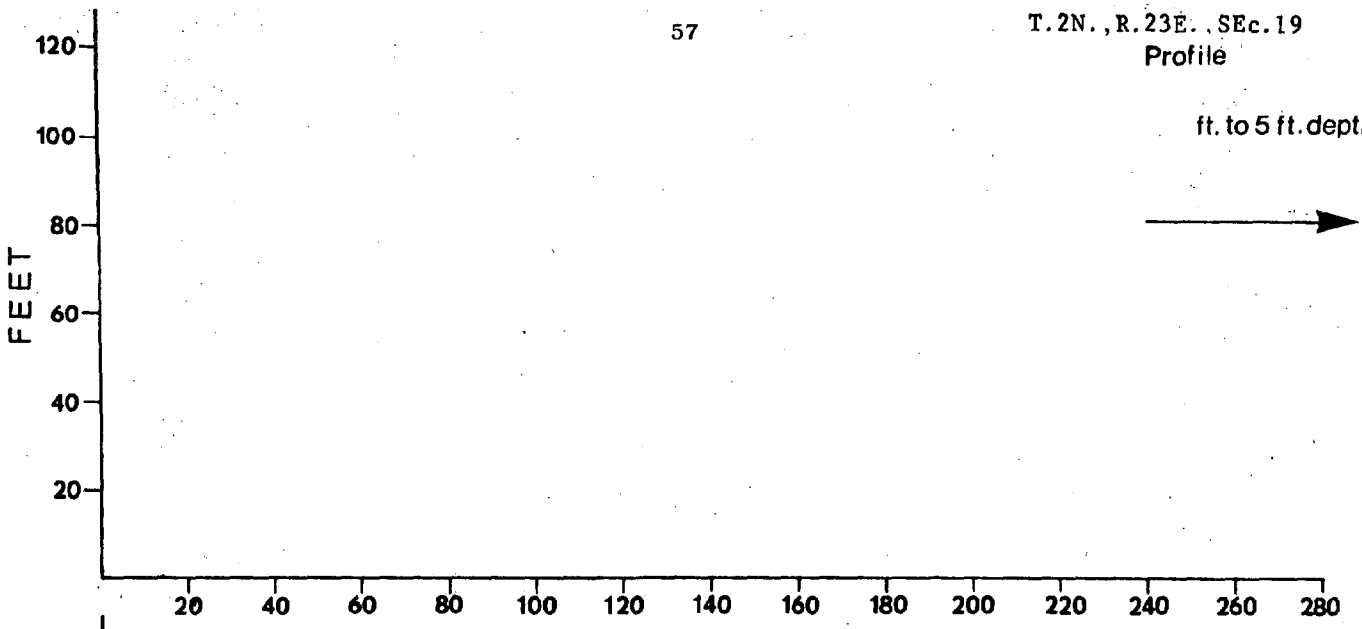
Profile 3

ft. to 5 ft. depth



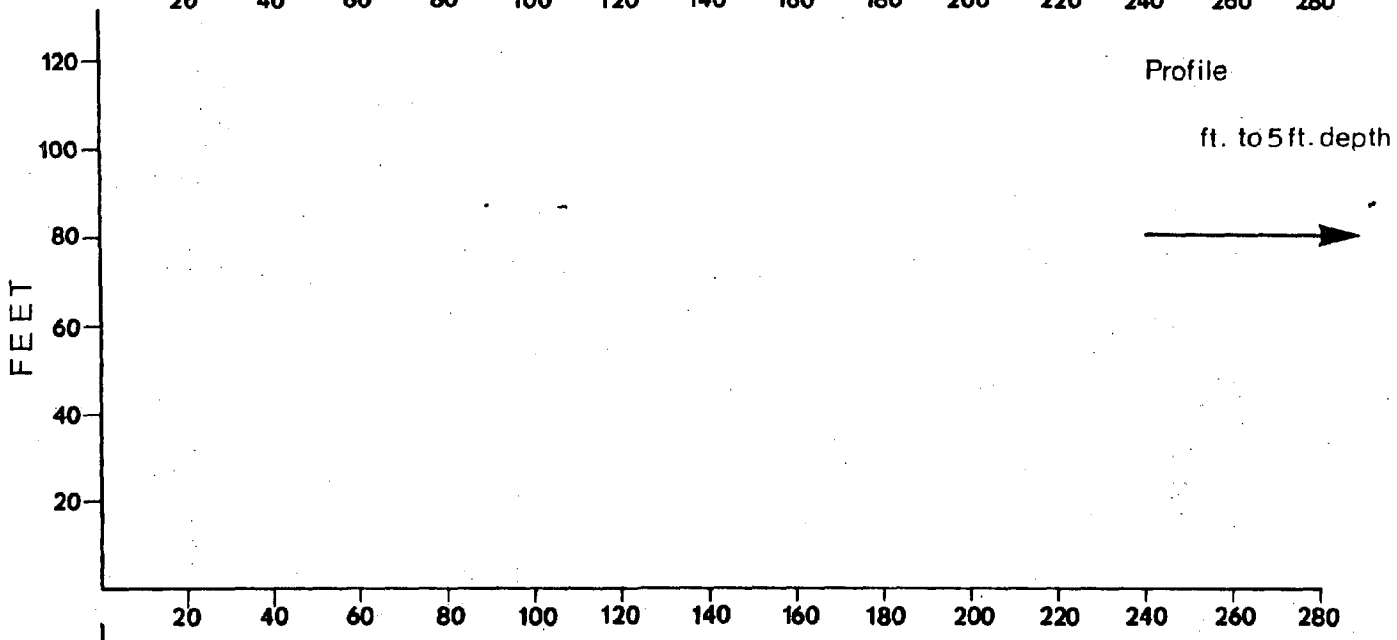
T.2N.,R.23E.,SEc.19
Profile

ft. to 5 ft. depth



Profile

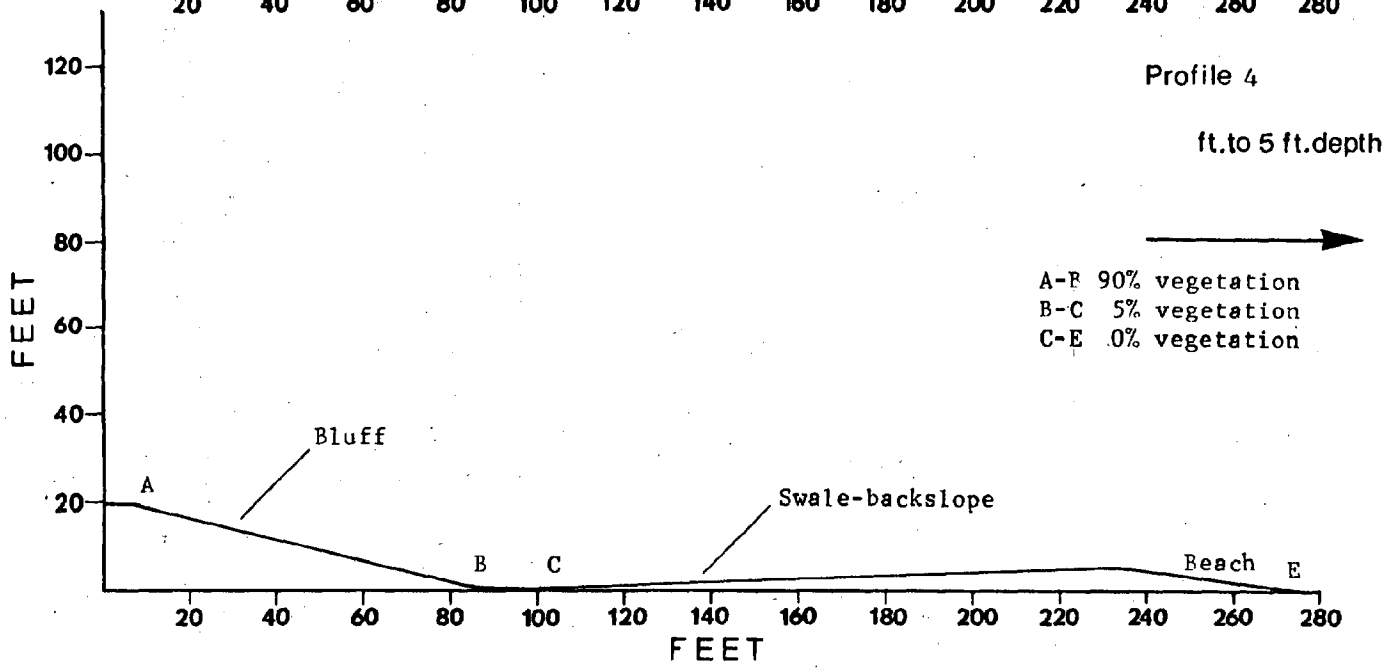
ft. to 5 ft. depth

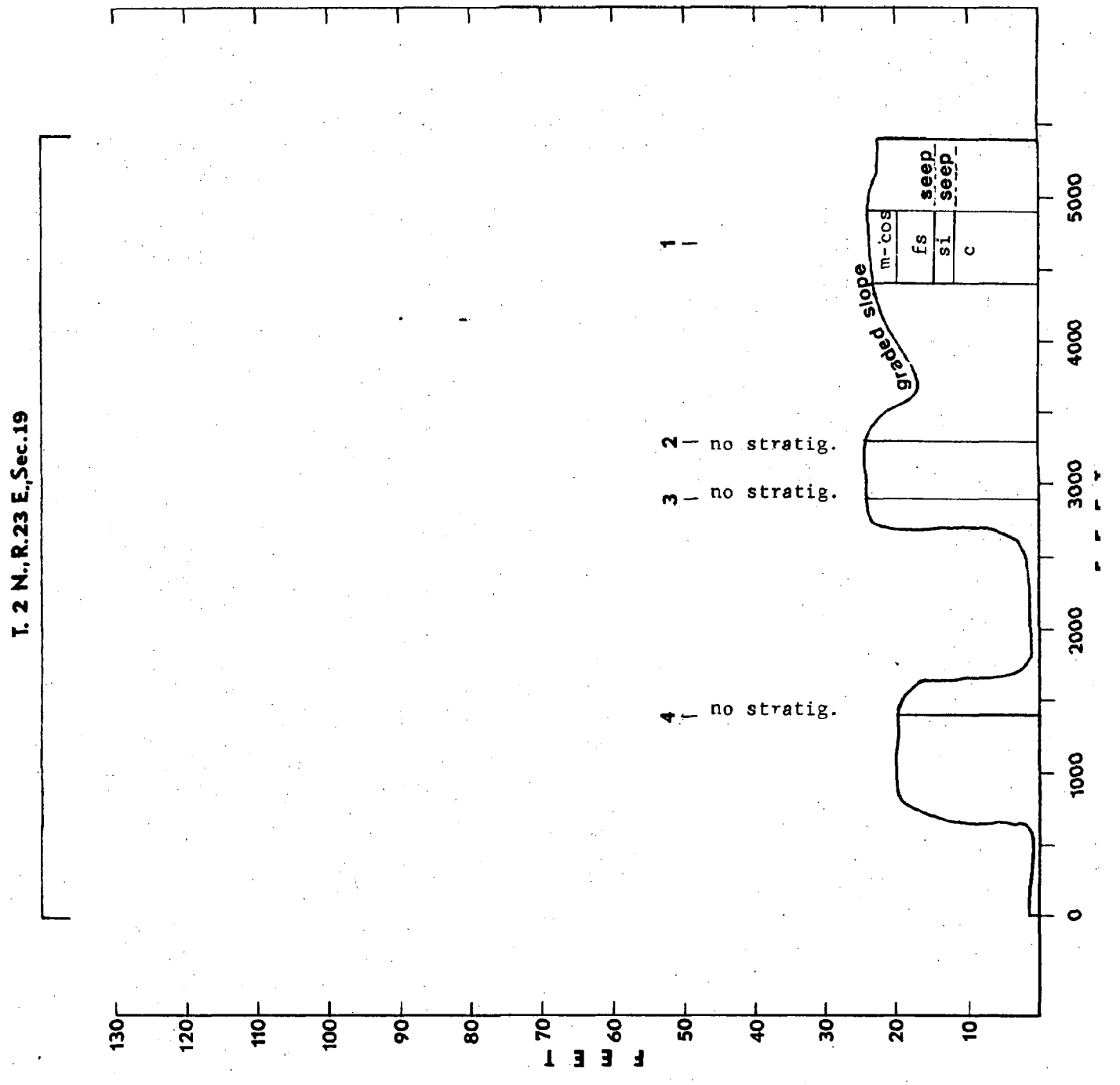


Profile 4

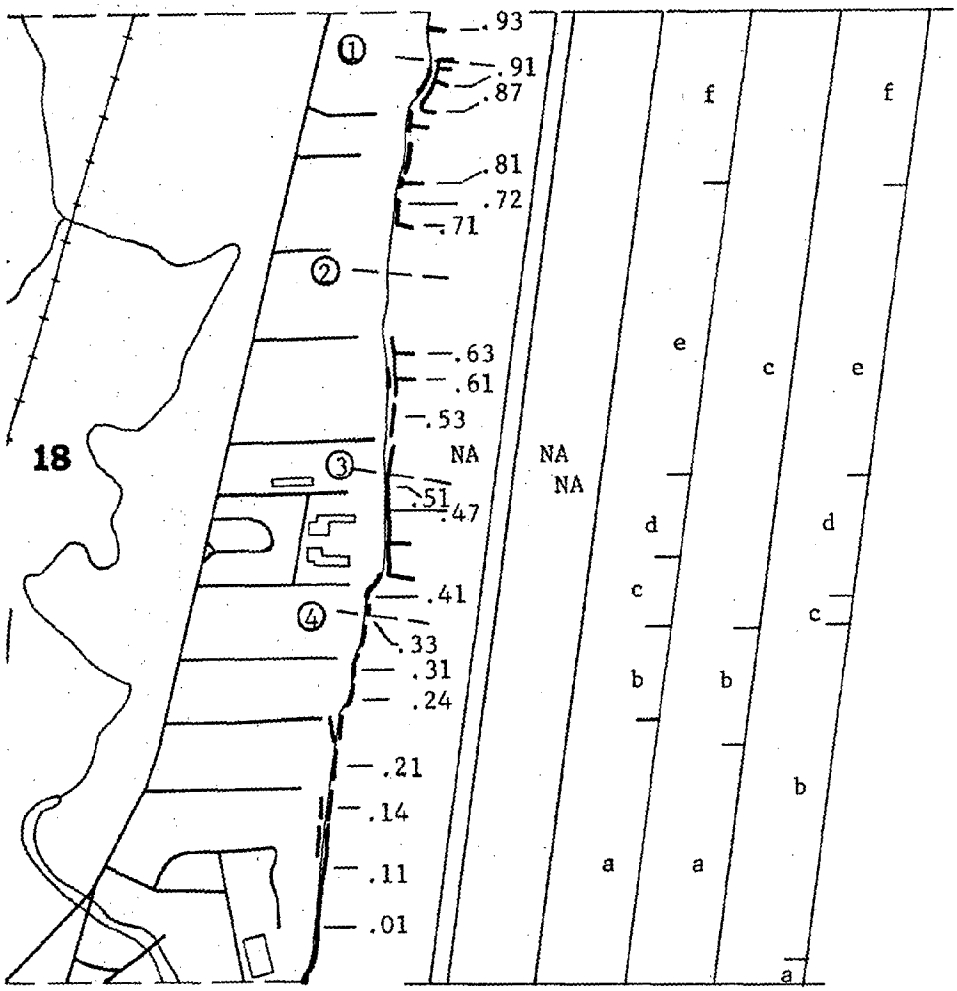
ft. to 5 ft. depth

A-B 90% vegetation
B-C 5% vegetation
C-E 0% vegetation




T. 2 N., R. 23 E., Sec. 19
FEET
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
1 —
2 — no stratig.
3 — no stratig.
4 — no stratig.
graded slope
m-cos
fs
si
c
seep
seep

T.2N.,R.23E.,Sec.18



SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

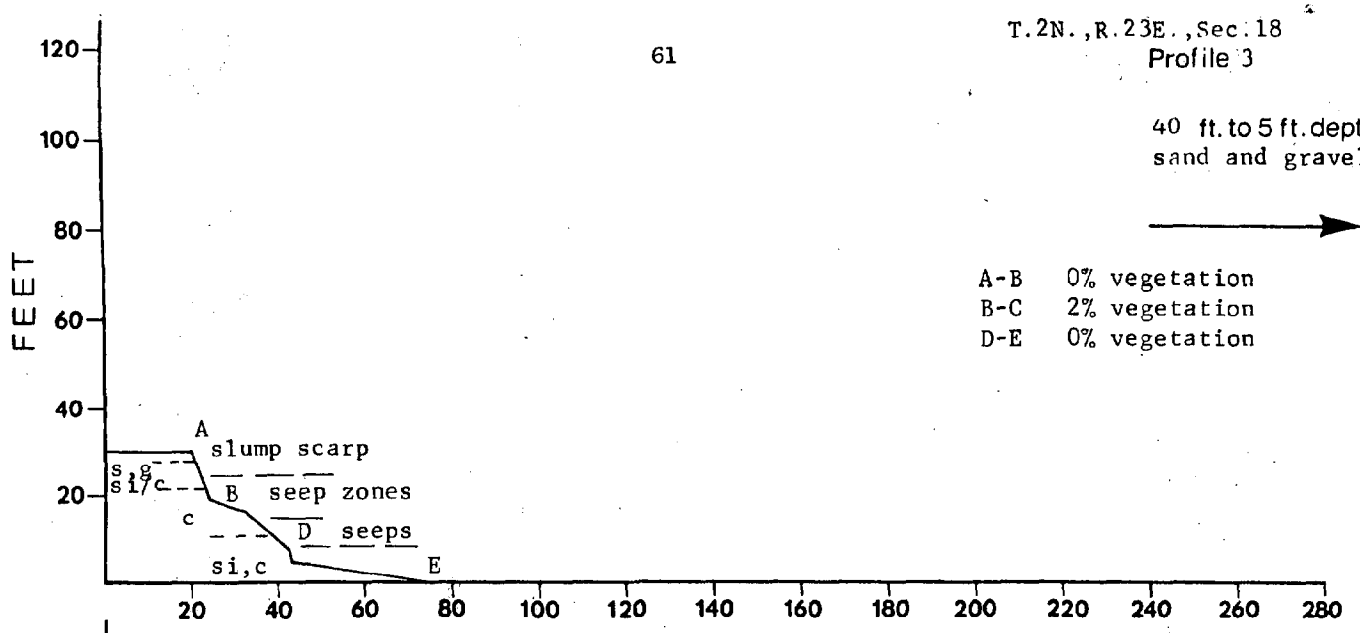
1.BLUFF	a-scalloped bluff edge, lacustrine silt-many places concealed with fill and debris,slump blocks along here in many places	b-mostly concealed, some slump areas in lacustrine silts	c-slumping in lacustrine silts	d-fairly stable grassed area
	e-scalloped bluff edge bluff here 25-30 ft. high-planar and rotational slump blocks in lacustrine silts	d-lacustrine silts with sand on top (2 ft.), slumping-scalloped bluff edge		
2. TOE	a-either concealed or lacustrine sediments in place or slumped	b-concealed	c-lacustrine silts mostly in place some slumped	
3. BEACH	a-less than 5 ft., cobbles	b-no beach	c-10 to 15 ft. sand and gravel	d-no beach
	e-less than 20 ft.,sand and gravel less than 40 ft. in places and 25 to 30 ft. in others.	f-0 to 5 ft. sand and gravel mostly gravel and cobbles toward south end of area		

T.2N.,R.23E.,Sec.18

Profile 3

40 ft. to 5 ft. depth
sand and gravel

A-B 0% vegetation
B-C 2% vegetation
D-E 0% vegetation

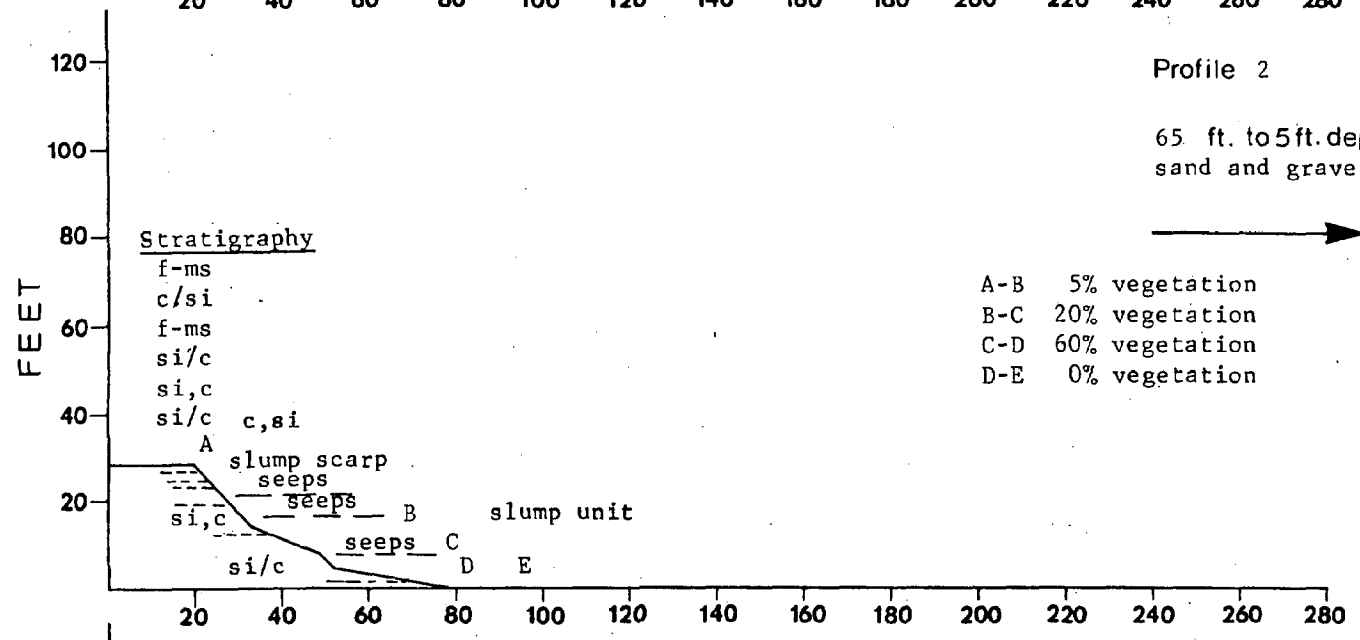


Profile 2

65 ft. to 5 ft. depth
sand and gravel

Stratigraphy
f-ms
c/si
f-ms
si/c
si,c
si/c c,si

A-B 5% vegetation
B-C 20% vegetation
C-D 60% vegetation
D-E 0% vegetation

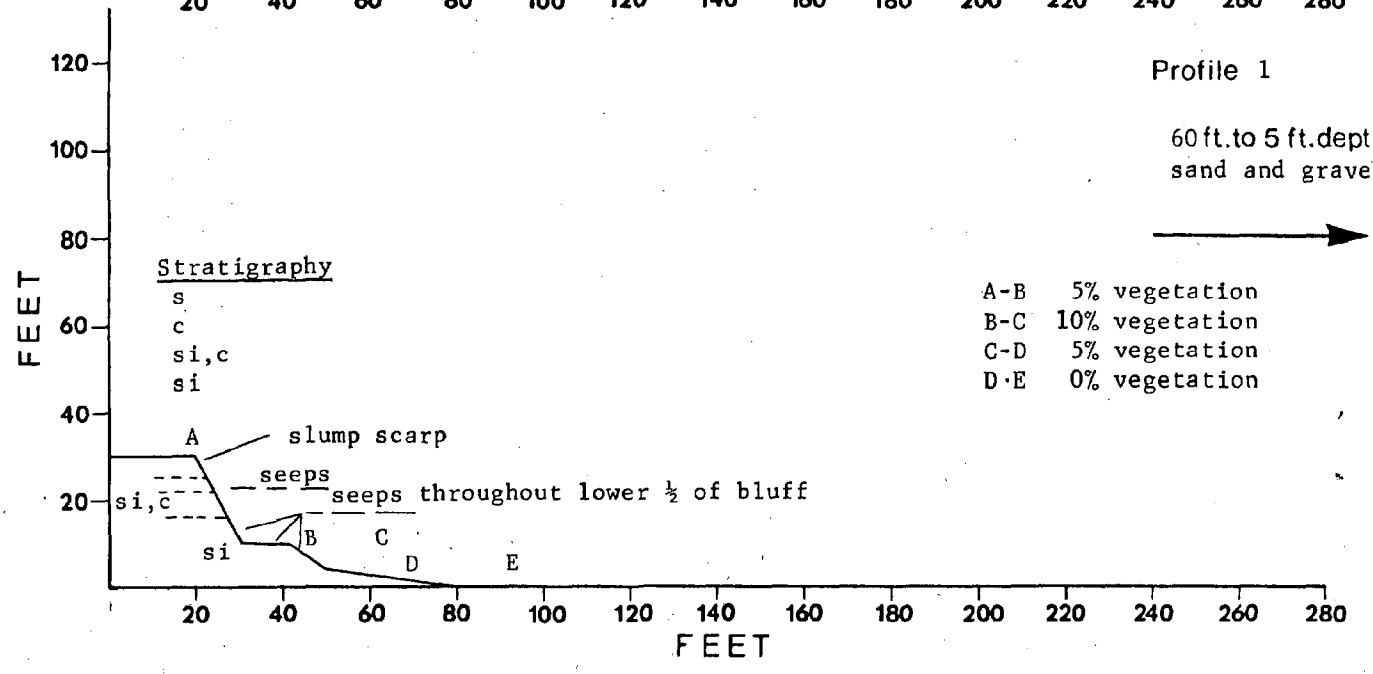


Profile 1

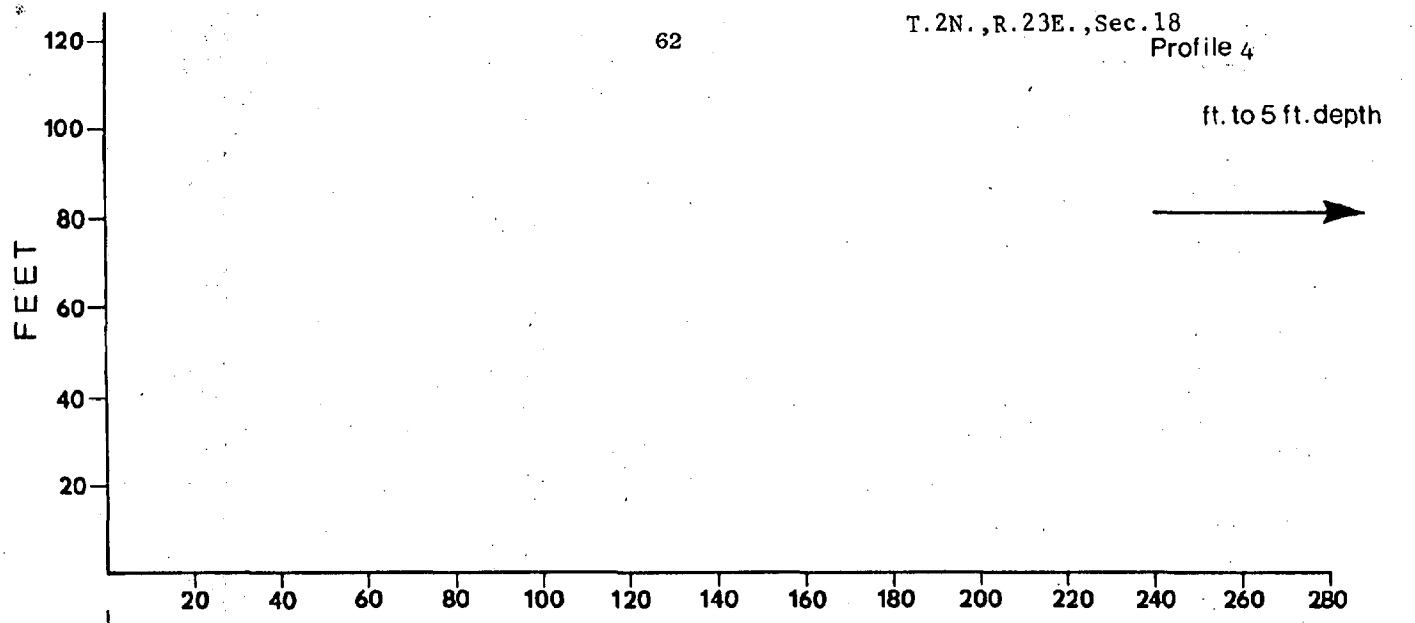
60 ft. to 5 ft. depth
sand and gravel

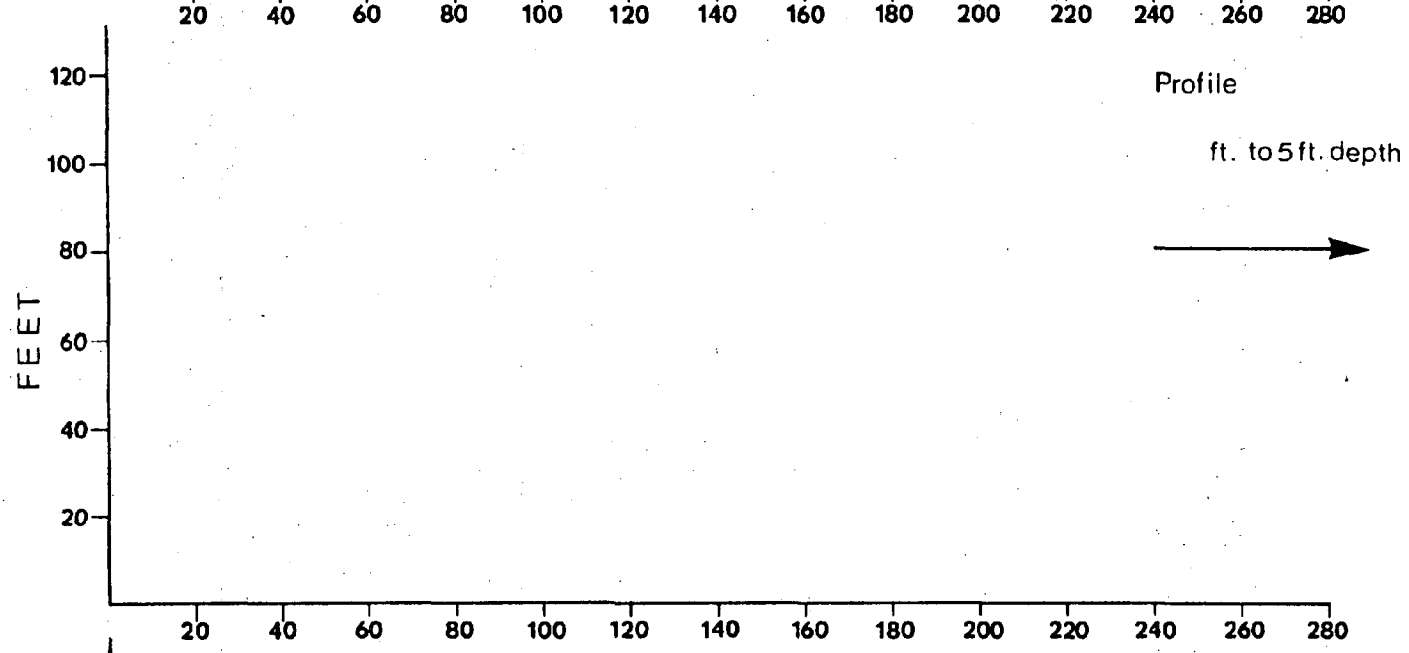
Stratigraphy
s
c
si,c
si

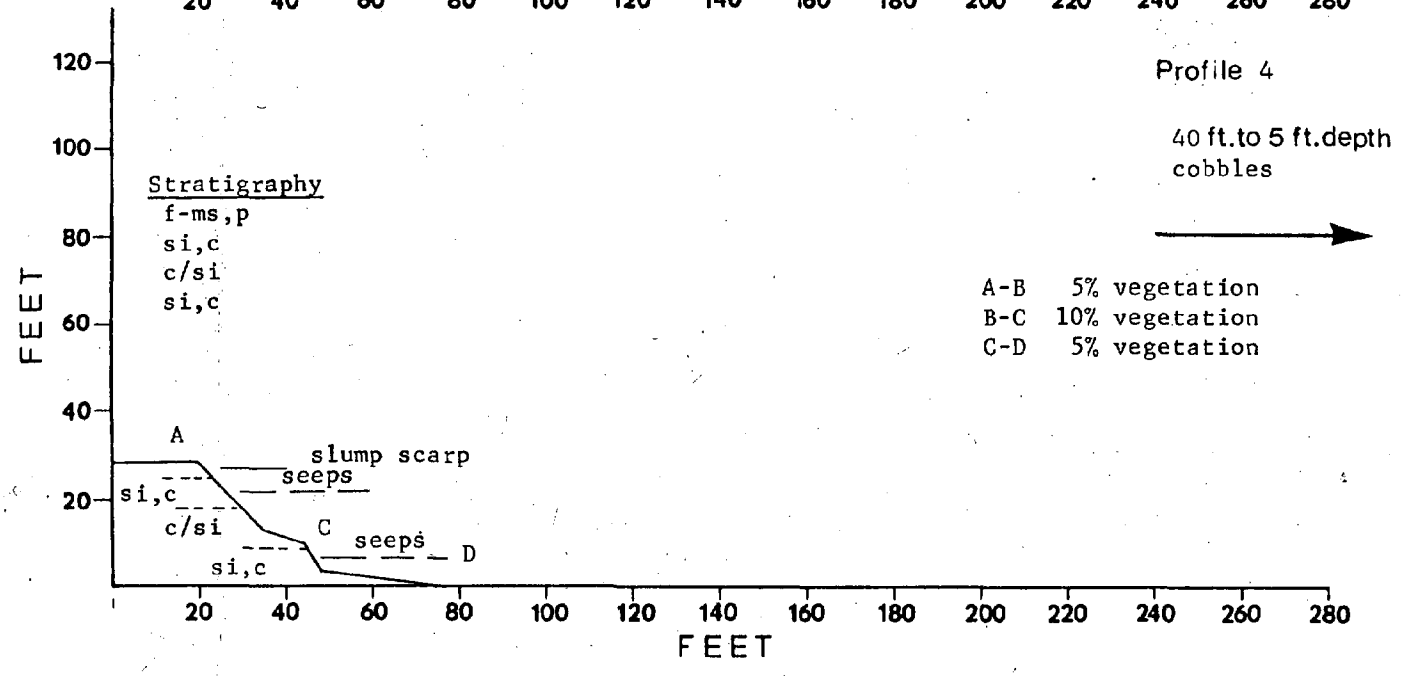
A-B 5% vegetation
B-C 10% vegetation
C-D 5% vegetation
D-E 0% vegetation

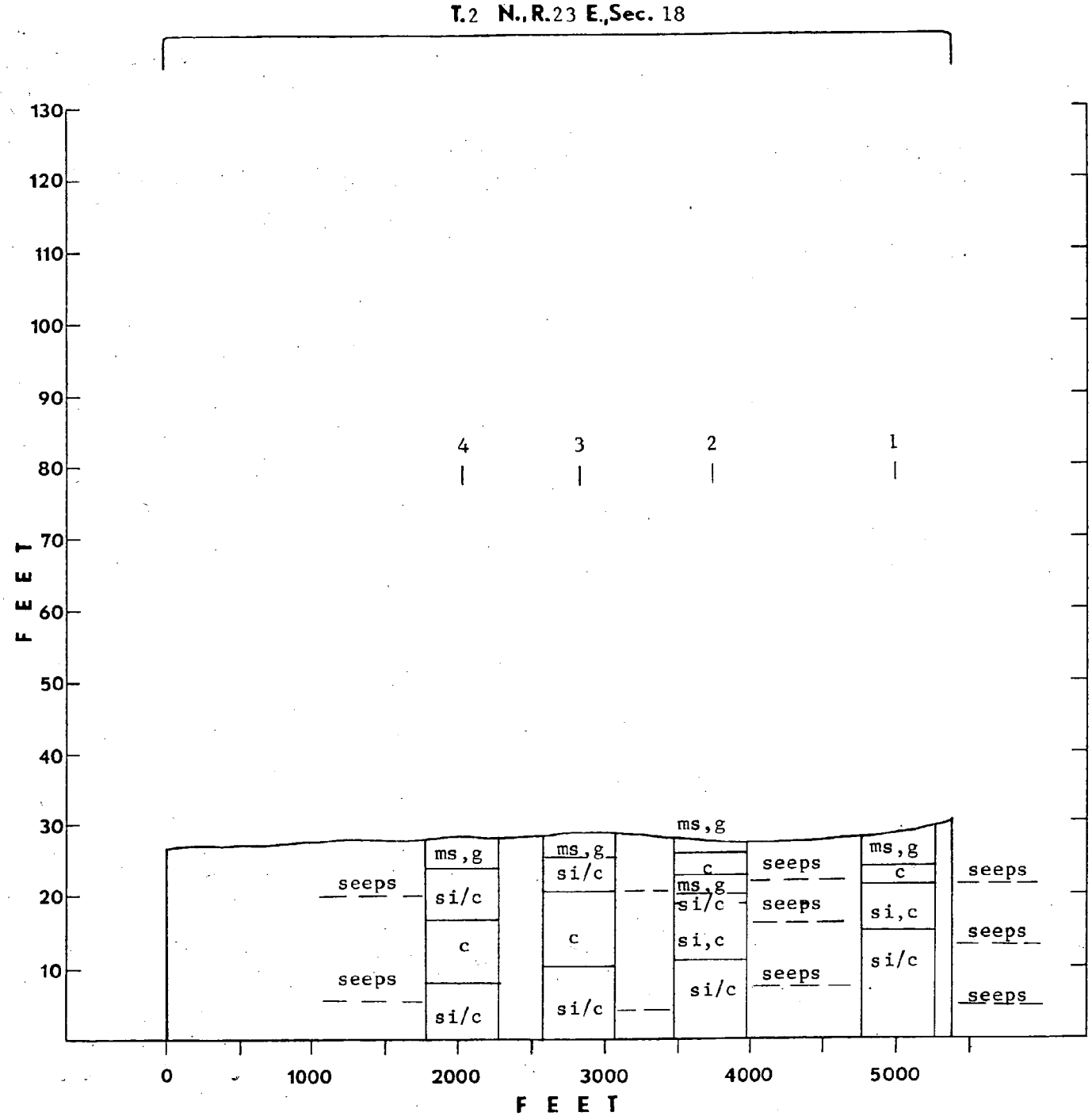


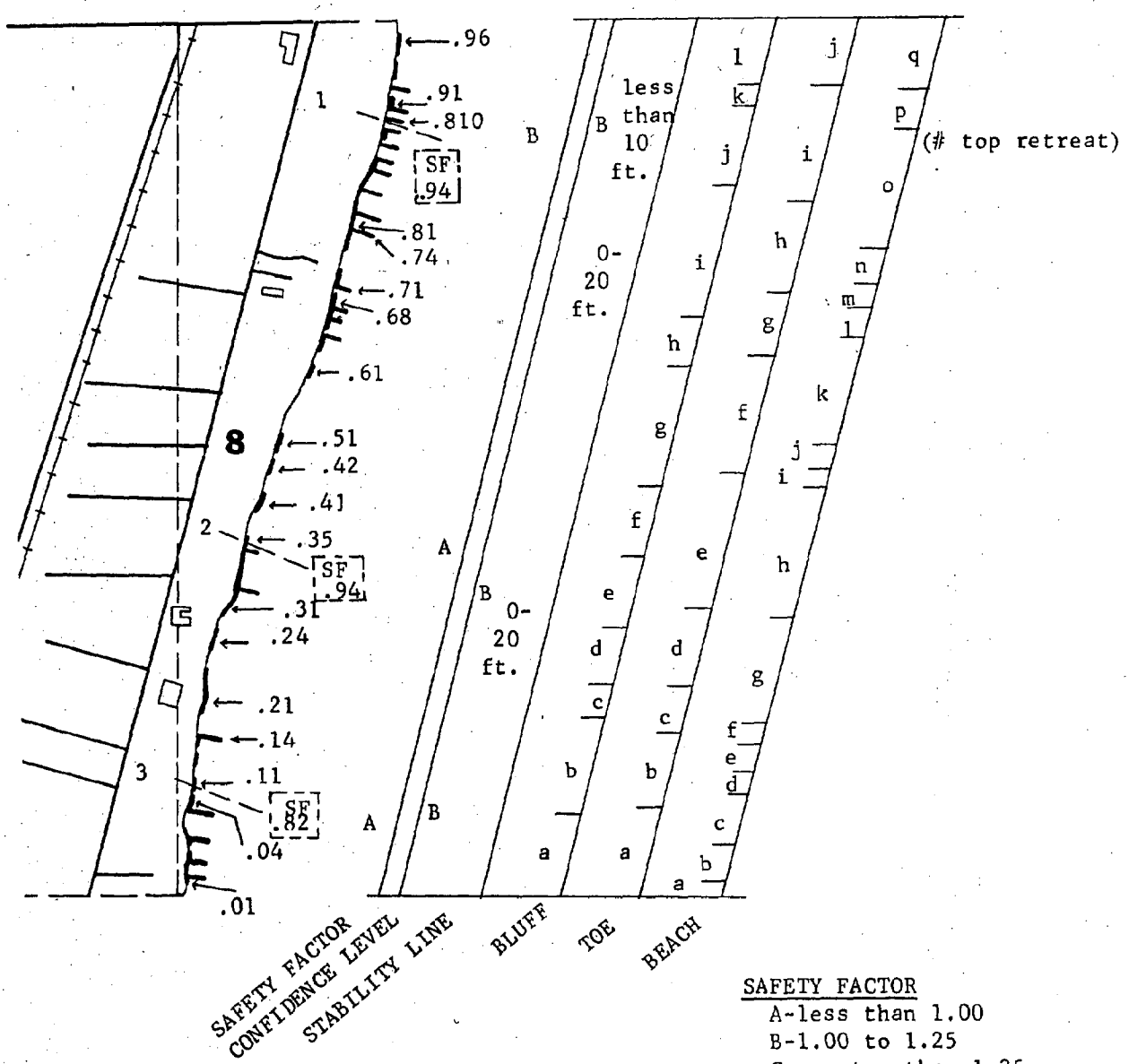
T.2N.,R.23E.,Sec.18








T.2 N., R.23 E., Sec. 18
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
4
3
2
1
ms,g
seeps
si/c
c
seeps
si/c
ms,g
si/c
c
si/c
ms,g
c
si,c
si/c
seeps
seeps
seeps
seeps
seeps
seeps
0
1000
2000
3000
4000
5000
FEET



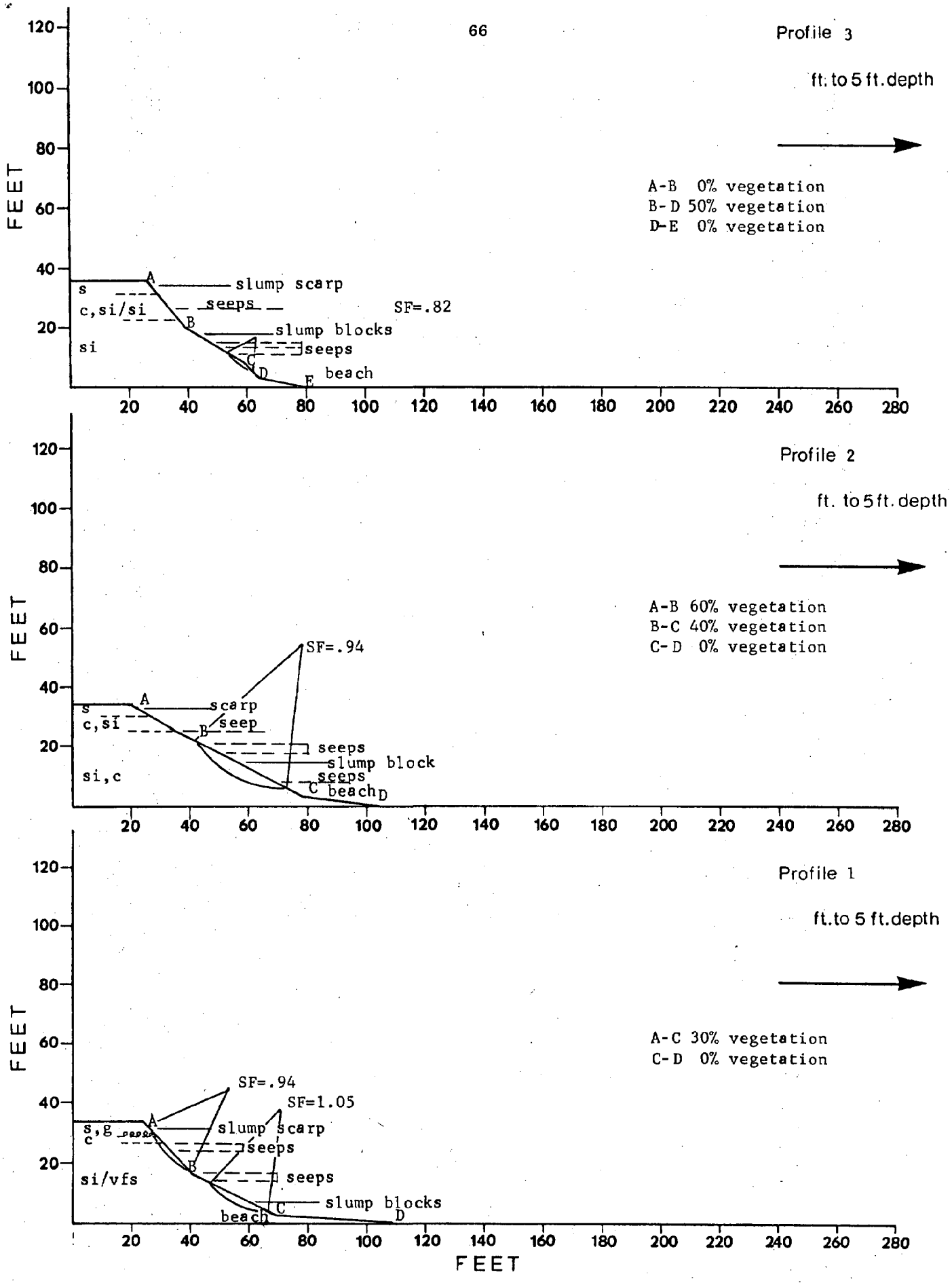
SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

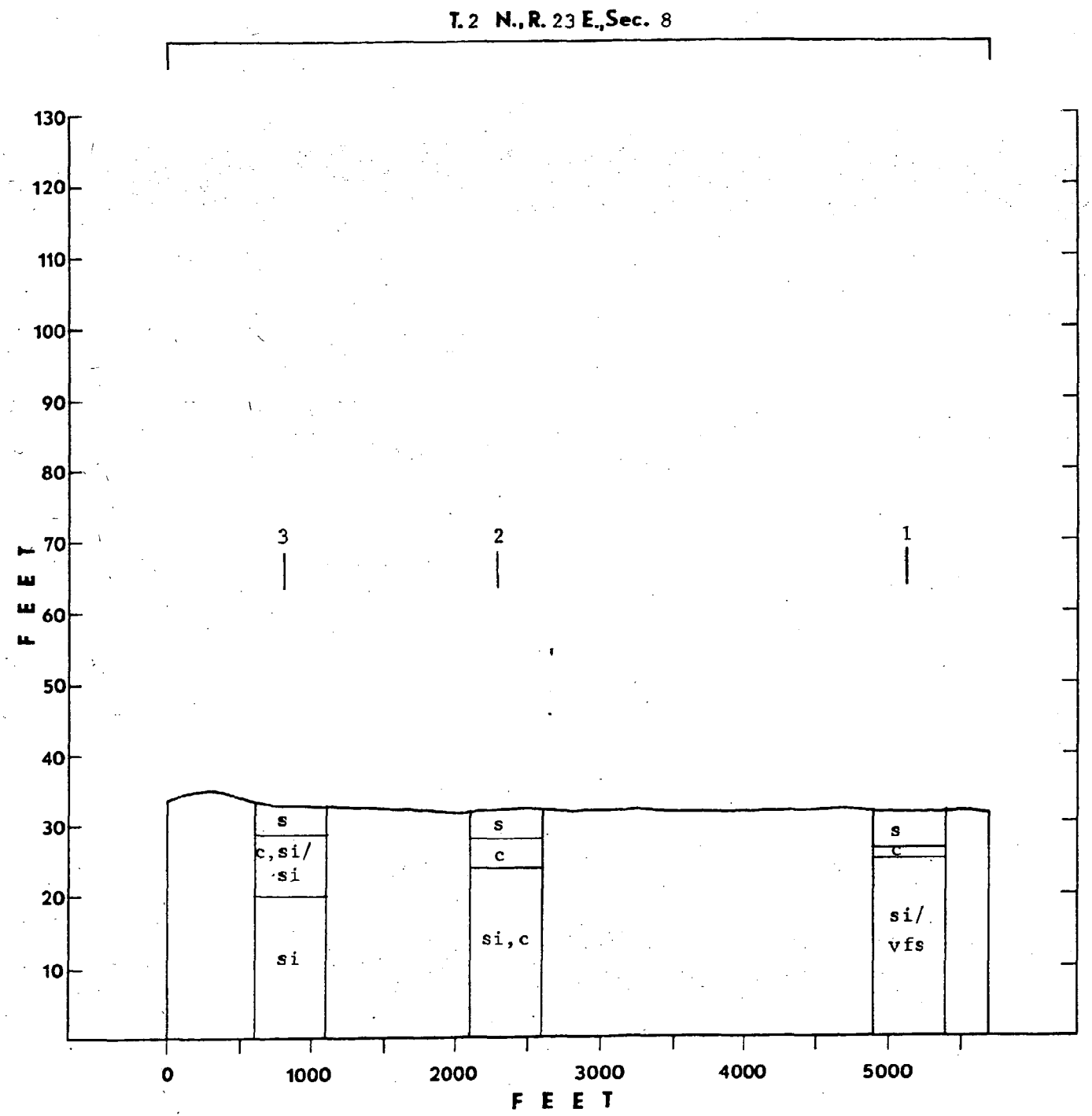
CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

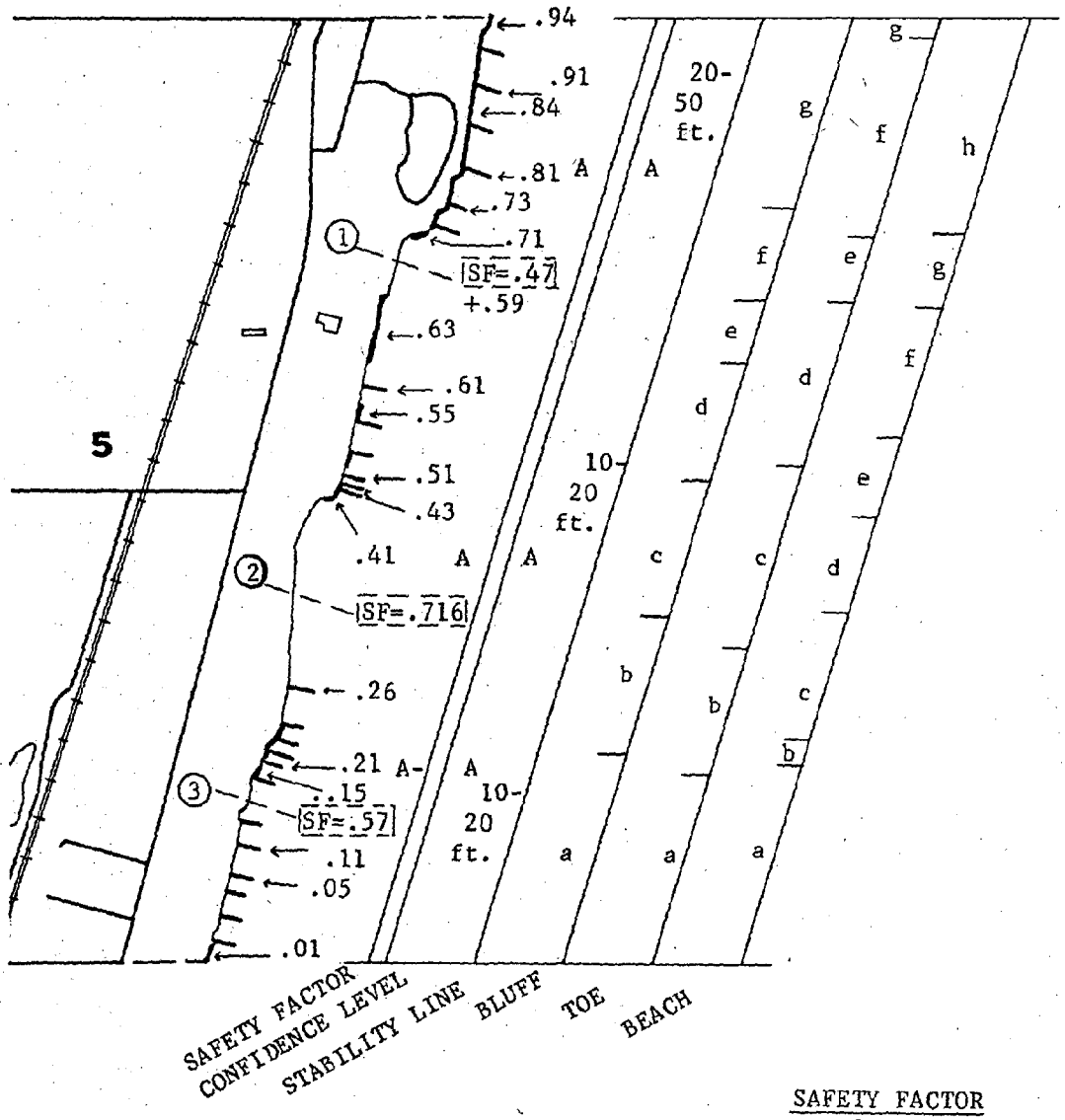
1. BLUFF	a-concealed fill piled on slopes	b-some toe erosion, but considerable vegetation-much fill	c-fill; slumped	d-till at toe bluff failing by slump and toe erosion	e-filled; concrete, debris, some slumping
	f-slumping; lacustrine sediments, planar slump, sand at top of bluff	g-fairly stable; vegetated	h-planar slump-previously graded	i-graded; eroding from runoff	j-lacustrine silt and clay slump area, bluff scalloped, seep zones in silt
	k-lacustrine silts with seep zones; bluff scalloped, slumps	l-bluff slumping in places; dangerous materials piled on slope			
2. TOE	a-concealed, some lacustrine sediment visible	b-concealed in some areas lacustrine silts and clay	c-slumped fill	d-till, in place	e-lacustrine silts, clays, in place and slump
	f-concealed, vegetated bluff	g-lacustrine silts and clays	h-lacustrine sediments and fill materials	i-lacustrine sediments silts and clays and sand either in place or slumped	j-concealed

T.2N., R.23E., Sec.8

3. BEACH	a-10-15 ft. sand and gravel	b- 5-10 ft. sand and gravel	c- -20 ft. sand and gravel	d-5-10 ft. sand and gravel	e- -5 ft. sand and gravel
	f- -20 ft. sand and gravel	g-no beach	h- -20 ft. sand and gravel, some small areas -10 ft.	i-5-10 ft. sand and gravel	j- -20 ft. sand and gravel
	k-5-10 ft. sand and gravel	l- -20 ft. sand and gravel	m-no beach	n- -20 ft. sand and gravel	o- no beach
	p- +20 ft. sand and gravel	q-no beach			


Profile 3
ft. to 5 ft. depth
A-B 0% vegetation
B-D 50% vegetation
D-E 0% vegetation
FEET
s
c,si/si
si
A
B
C
D
E
slump scarp
seeps
SF=.82
slump blocks
seeps
beach
Profile 2
ft. to 5 ft. depth
A-B 60% vegetation
B-C 40% vegetation
C-D 0% vegetation
SF=.94
s
c,si
si,c
A
B
C
D
scarp
seep
seeps
slump block
seeps
beach
Profile 1
ft. to 5 ft. depth
A-C 30% vegetation
C-D 0% vegetation
SF=.94
SF=1.05
s,g
c
si/vfs
A
B
C
D
slump scarp
seeps
seeps
slump blocks
beach
120
100
80
60
40
20
20 40 60 80 100 120 140 160 180 200 220 240 260 280
FEET


T. 2 N., R. 23 E., Sec. 8
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
3
2
1
s
c, si/ si
si
s
c
si, c
s
c
si/ vfs
0
1000
2000
3000
4000
5000
FEET

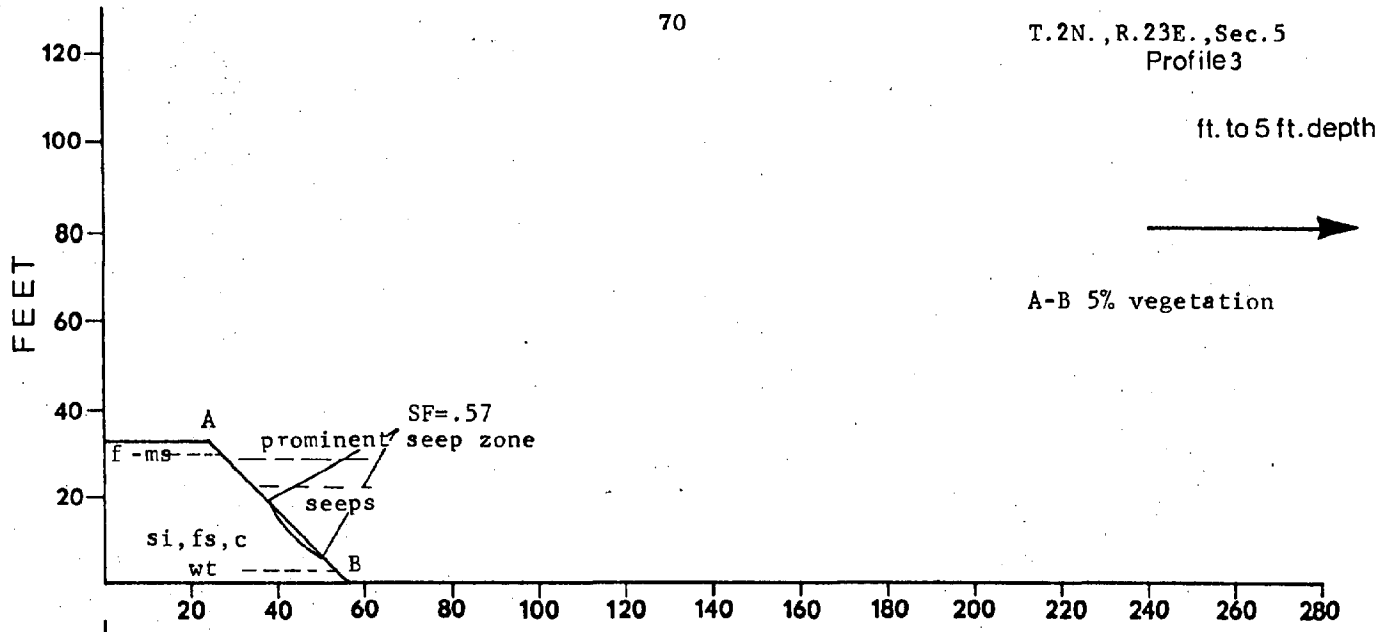


SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

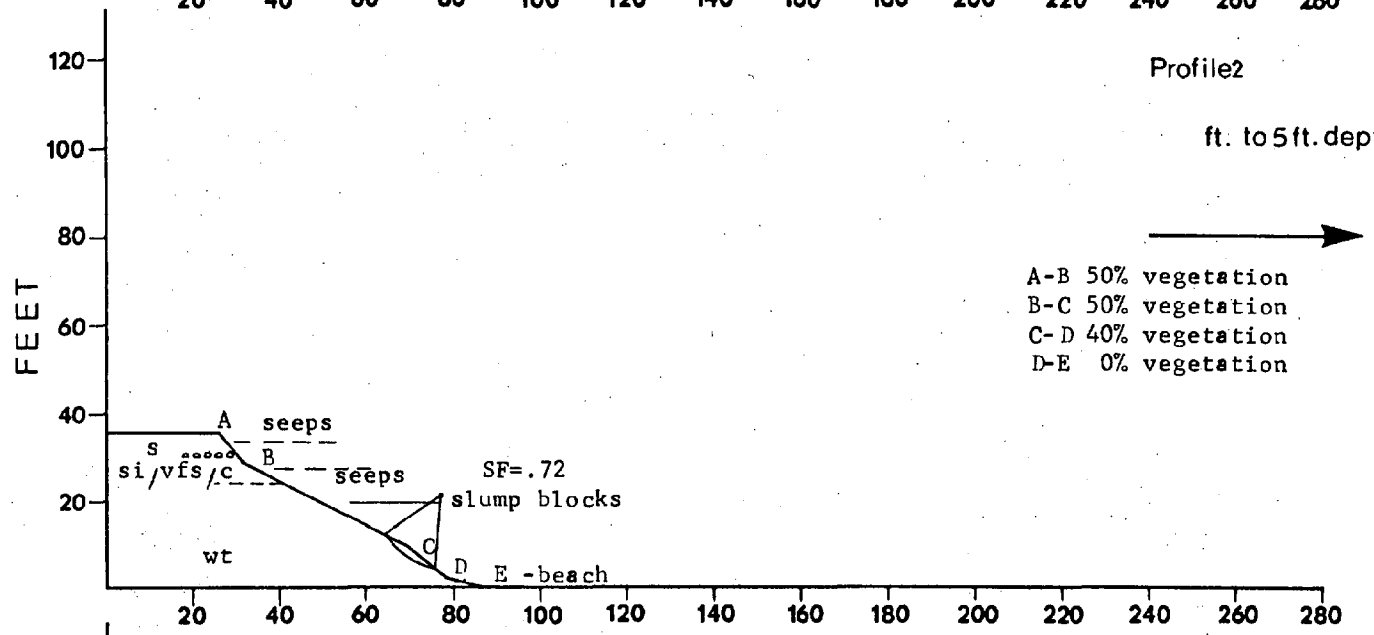
CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-severe rotational and planar slump- toe erosion (waves) and slides and flows, scalloped bluff edge	b-fairly stable; vegetated, lawns,etc.	c-severe rotational slump, wave erosion	d-slope piled with debris; failing by slump	e-graded bluff
	f-moderate to severe planar slump	g-relatively stable, vegetated and terraced			
2. TOE	a-till overlain by lacustrine sediment, some slump, some in place	b-unobservable; lawns,etc.	c-till,in place,some slump also	d-mostly unobservable; where visible, toe is till	e-till
	f-unobservable; stuctures and graded lawns	g-till, in place			
3. BEACH	a- -5 ft. sand and gravel	b-0-5 ft. gravel	c-20-40 ft. sand and gravel	d-15-20 ft. sand and gravel	e-5-15 ft. cobbles and gravel
	f- -5 ft. cobbles, gravel, mostly no beach	g-10-15 ft. pebbles and gravel	h-no beach		

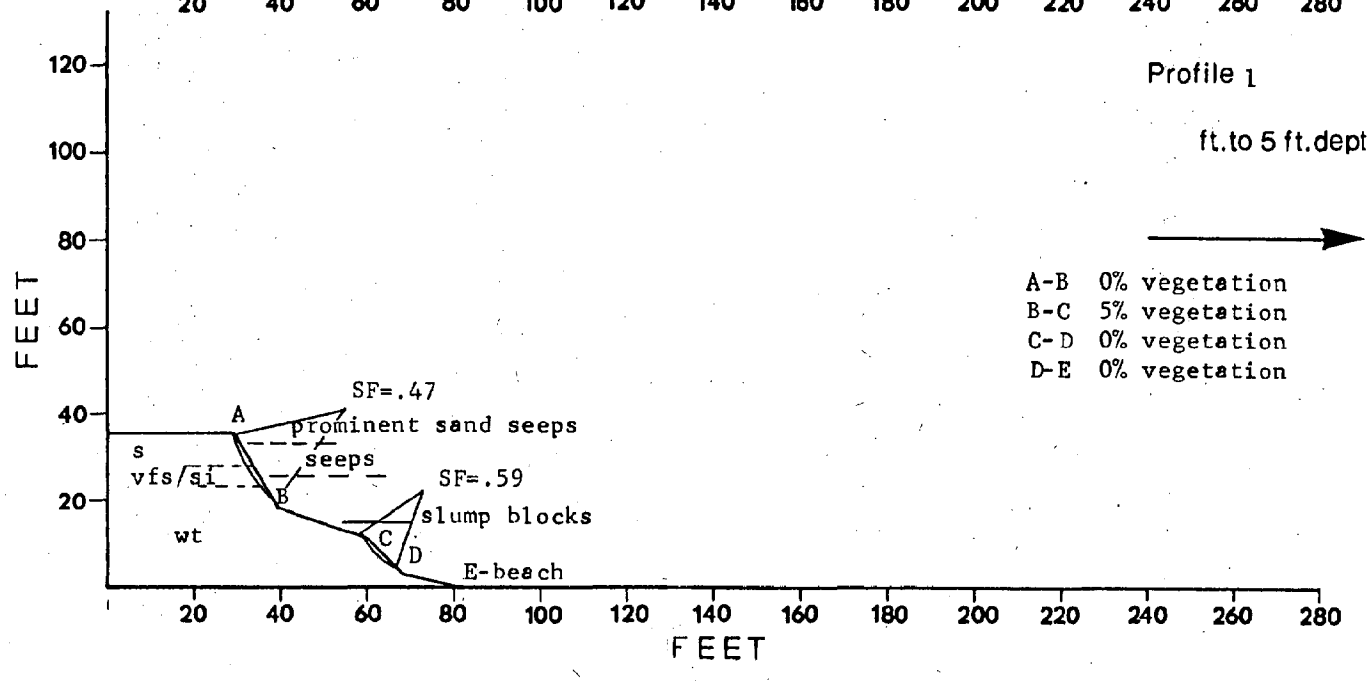
T.2N., R.23E., Sec.5
Profile 3

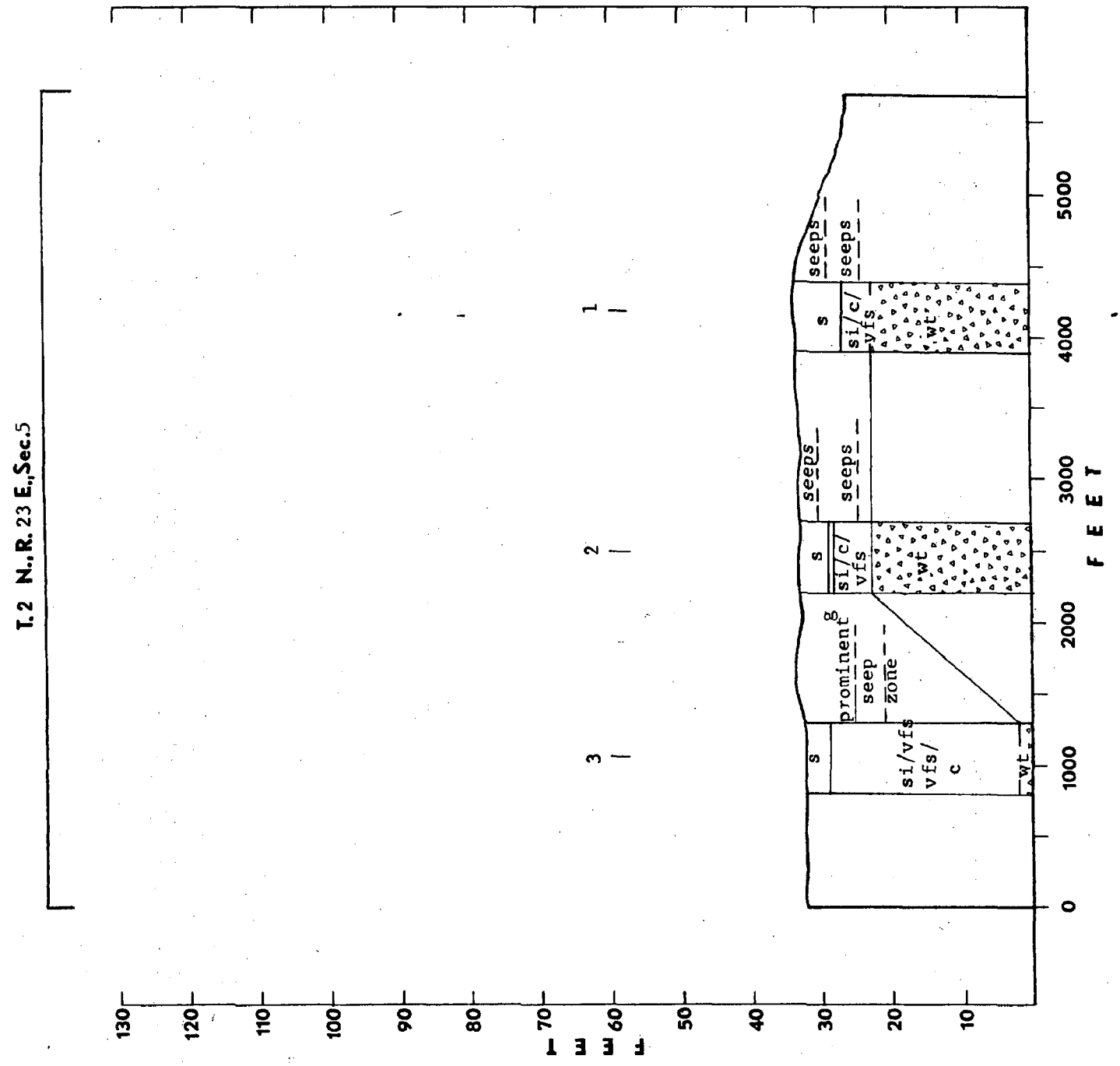


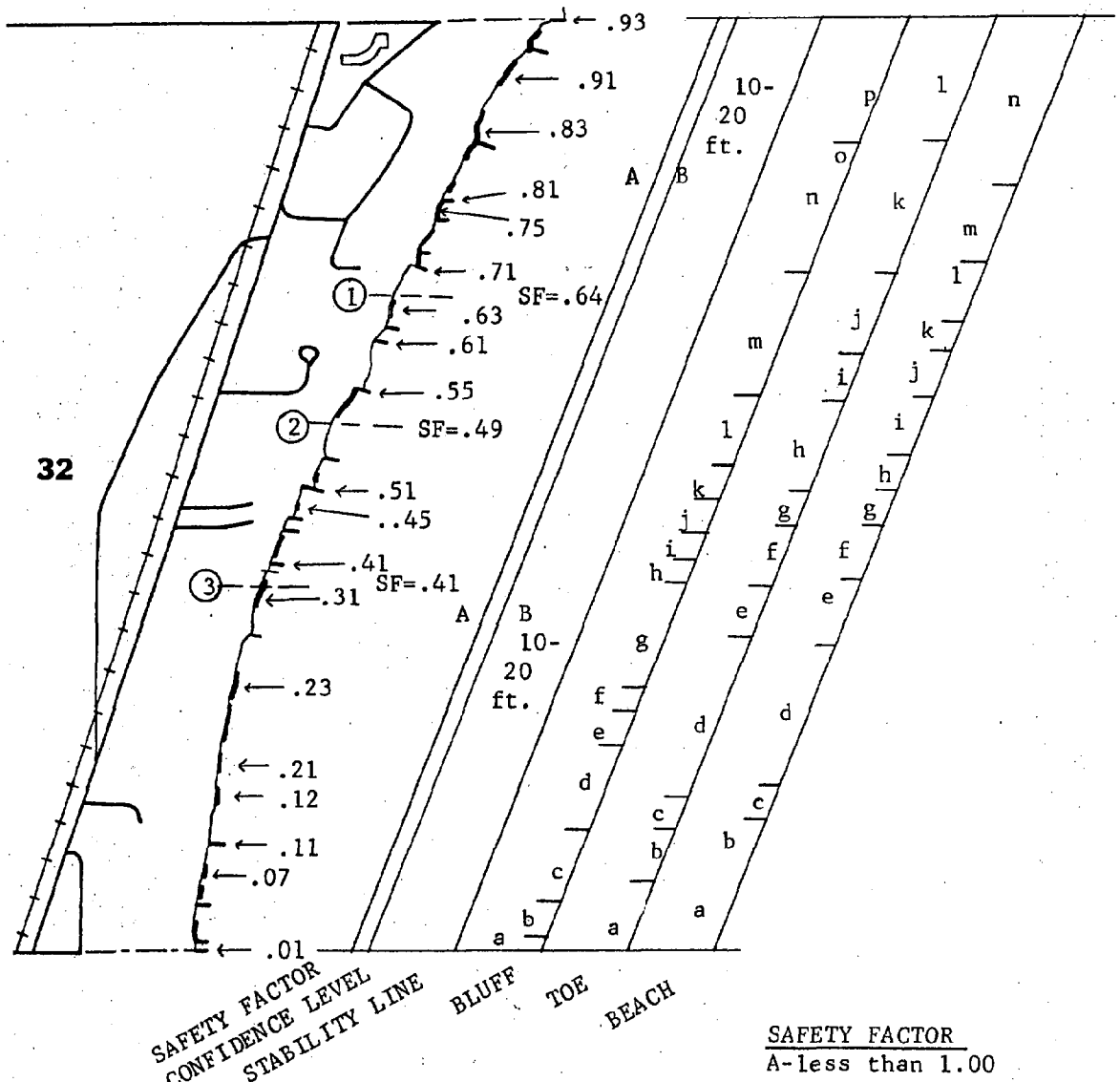
Profile 2



Profile 1




T. 2 N., R. 23 E., Sec. 5
1
2
3
s
si/vfs/c
wt
prominent seep zone
si/c/vfs
wt
seeps
seeps
s
si/c/vfs
wt
seeps
seeps
FEET
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
FEET

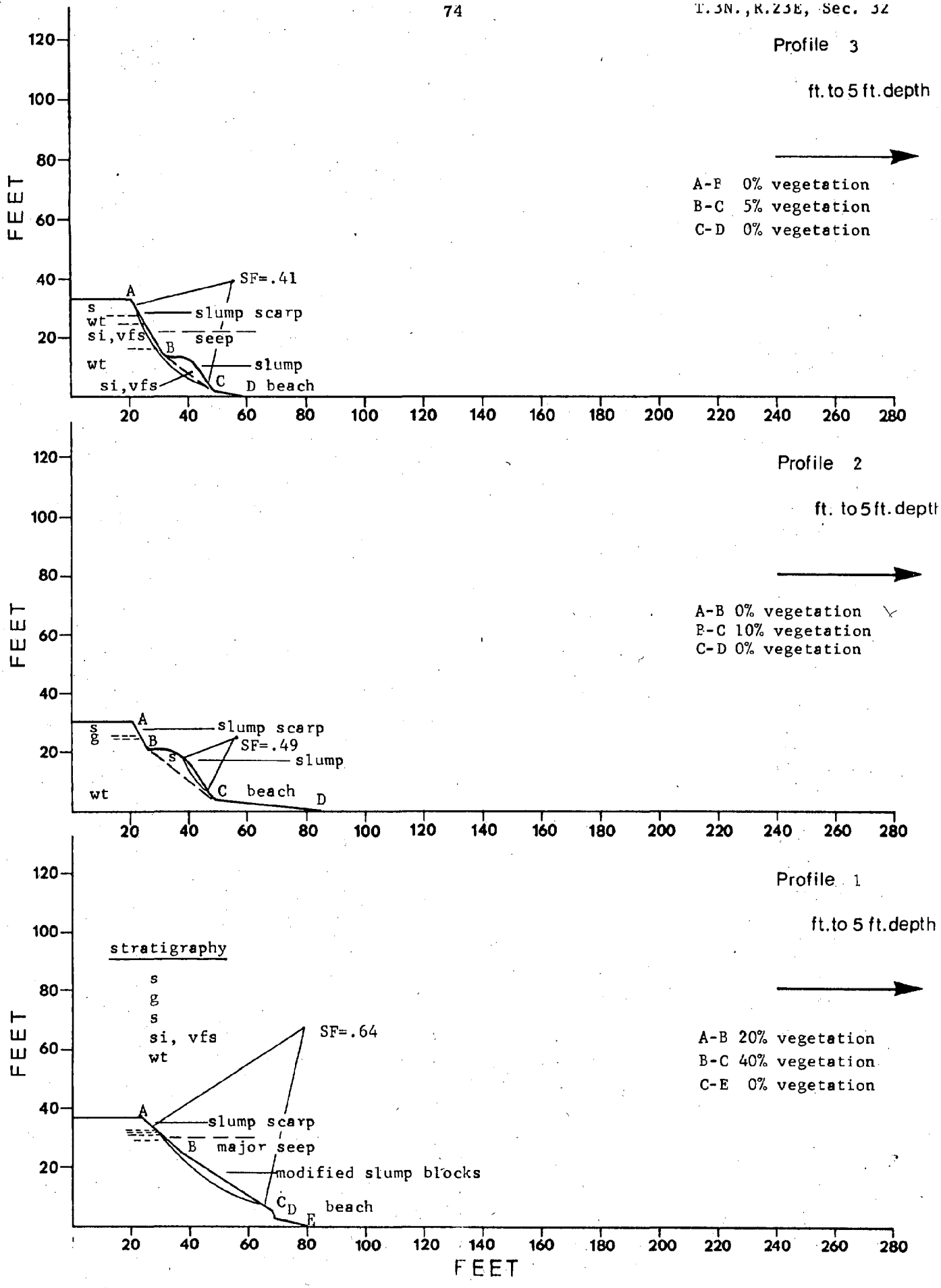


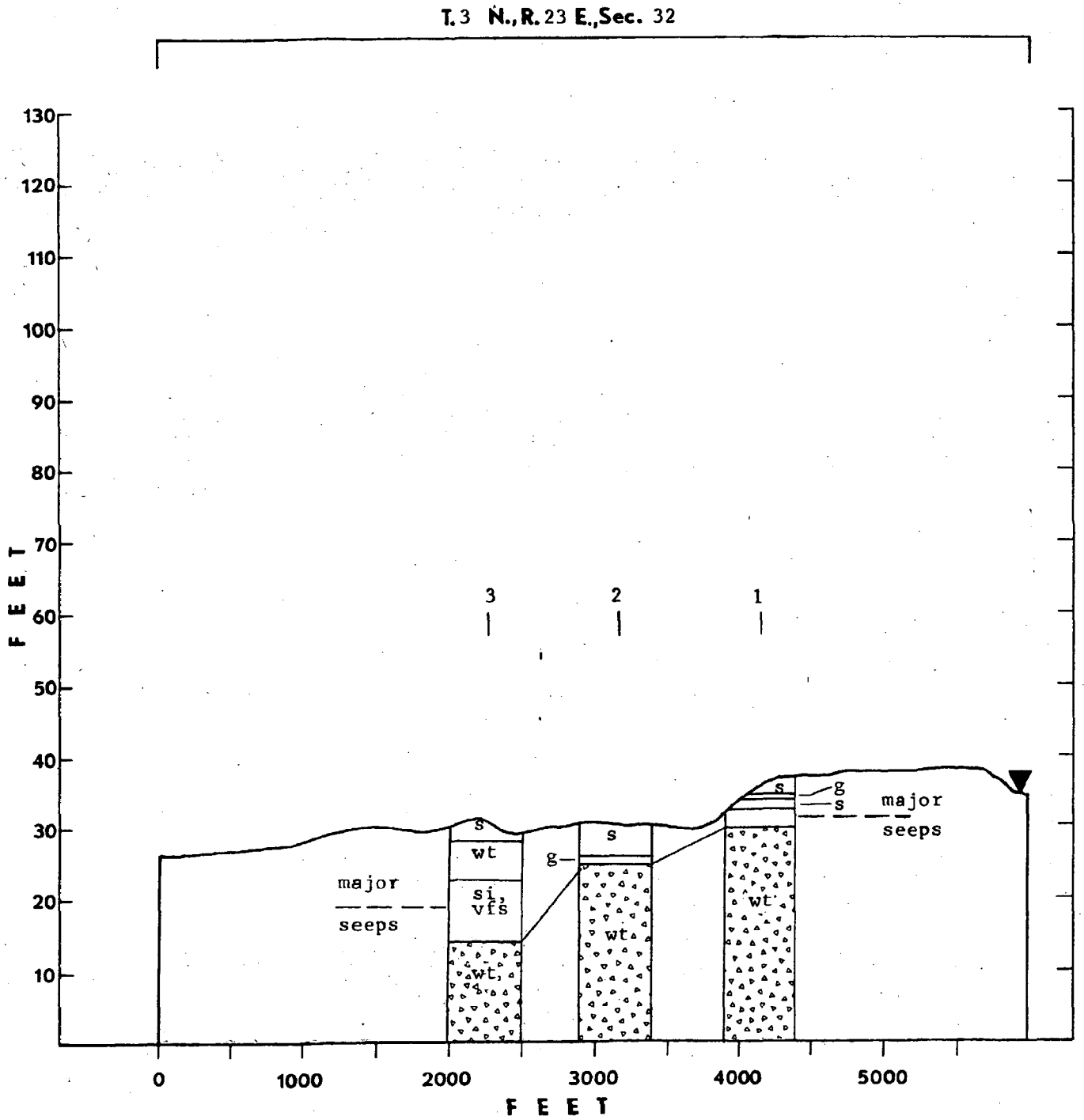
SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

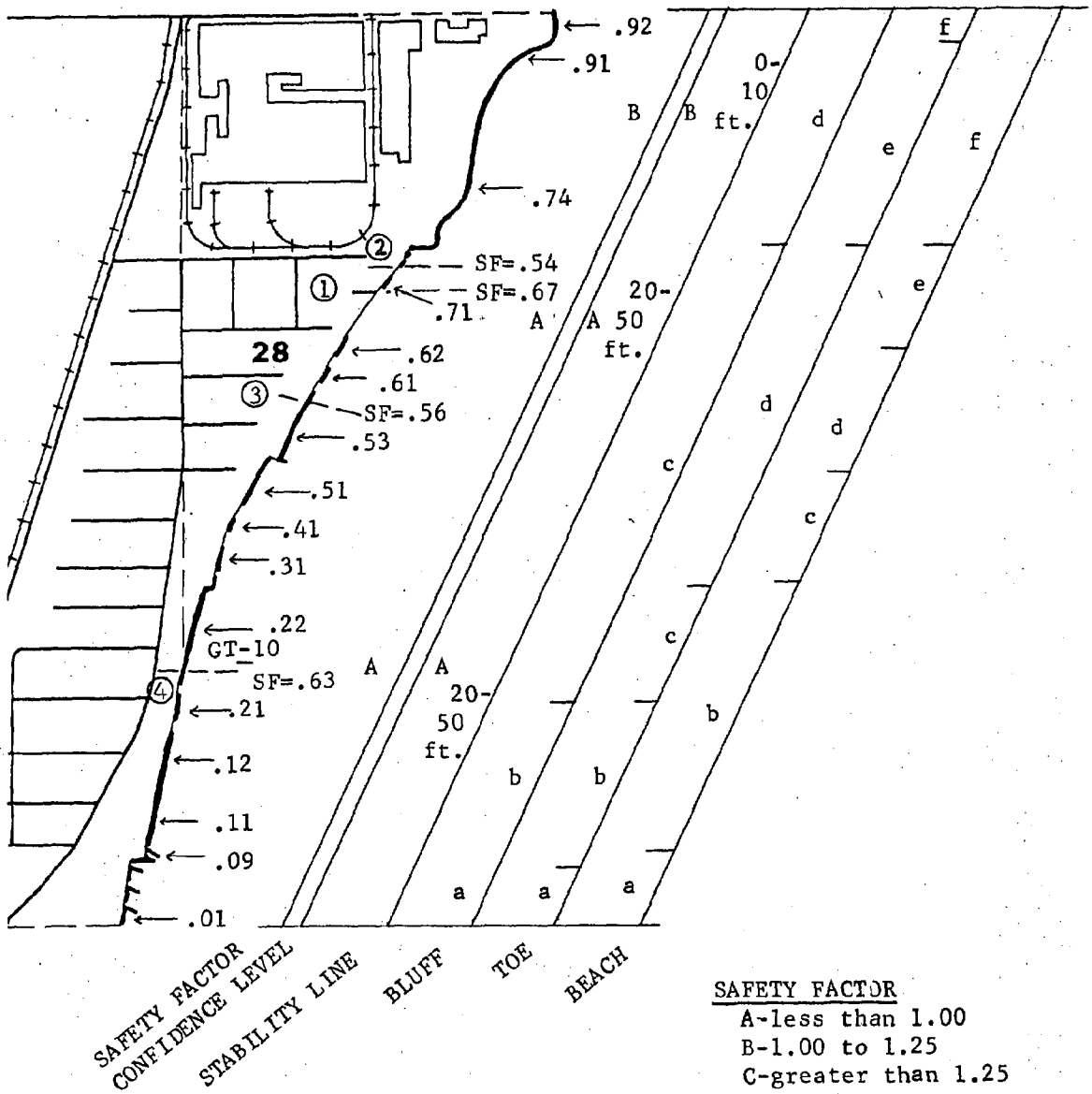
T.3N.,R.23E.,Sec.32

1. BLUFF	a-slump, rotational and planar	b-stable, graded, terraced	c-stable, vegetated	d-large slump block (planar) scalloped bluff edge
	e-rubbish strewn on slope, dangerous	f-graded, stable with large seawall	g-severe slump (planar), also by debris fall	h-severe erosion by slump, seeps in lacustrine silts, sand, scalloped bluff edge
	i-seeps, failure by slide and flow, till, scalloped bluff edge	j-stable, small old slumps	k-filled	l-filled
	m-stable vegetated	n-till and lacustrine soils at very top, some sand and gravel, scalloped bluff, slump, slides and flow tongues	o-failing here, slump slides	p-till, filled concrete, earth, bricks, debris, some unobservable spring midway up slope
2. TOE	a-till or slump	b-graded, concealed	c-till and slump (sand)	d-till, slumped lacustrine sediments or till
	e-till or slump	f-till, slump	g-concealed	h-fill, debris
	i-concealed	j-till	k-till	l-mostly fill, some till visible
3. BEACH	a-no beach	b-greater than 20 ft. gravel	c-5 to 10 ft. sand and gravel	d-less than 5 ft., sand and gravel
	e-15 to 20 ft., sand and gravel	f-less than 5 ft., sand	g-greater than 20 ft., sand and gravel	h-10 to 15 ft., sand and gravel
	i-no beach	j-greater than 20 ft., sand and gravel	k-20 ft., sand and gravel	l-0 to 15 ft., sand and gravel
	m-10 to 15 ft., sand and gravel	n-no beach		


Profile 3
ft. to 5 ft. depth
A-B 0% vegetation
B-C 5% vegetation
C-D 0% vegetation
SF=.41
slump scarp
seep
slump
beach
s
wt
si,vfs
wt
si,vfs
A
B
C
D
Profile 2
ft. to 5 ft. depth
A-B 0% vegetation
B-C 10% vegetation
C-D 0% vegetation
slump scarp
SF=.49
slump
beach
s
g
wt
A
B
C
D
Profile 1
ft. to 5 ft. depth
A-B 20% vegetation
B-C 40% vegetation
C-E 0% vegetation
stratigraphy
s
g
s
si, vfs
wt
SF=.64
slump scarp
major seep
modified slump blocks
beach
A
B
C
D
E
FEET
FEET
120
100
80
60
40
20
20 40 60 80 100 120 140 160 180 200 220 240 260 280


T. 3 N., R. 23 E., Sec. 32
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
3
2
1
s
wt
si, vfs
wt
major
seeps
g
s
wt
wt
s
g
s
major
seeps
0
1000
2000
3000
4000
5000
FEET

T.3N.,R.23E.,Sec.28/29



SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

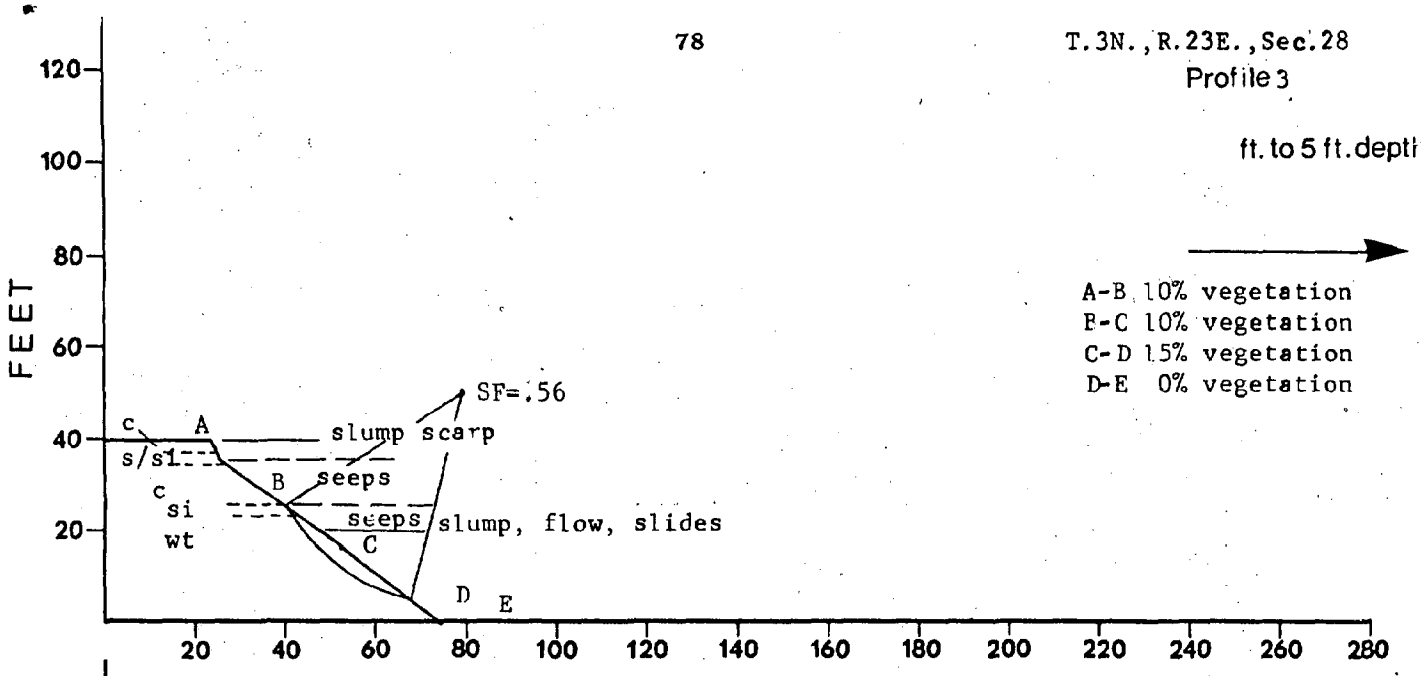
CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-failure by slump	b-bluff consists of recent artificial fill	c-serious slope failure caused by slump, debris flow; also by the erosion, surface water coming over top of bluff, water issuing from seep zones in silt and sands above till. Foundations undercut and exposed. Scalloped bluff margin, slump scarps at top of bluff.	d-artificial fill;slope in back of revetment is vegetated and appears stabilized.
2. TOE	a-natural toe material is till, covered in most places by slump or artificial fill debris.	b-toe material consists mostly of artificial fill and debris dumped over top of bluff (broken concrete,slag, iron,bicycles, kitchen sinks)	c-dolomite blocks (revetment), with till behind	d-natural toe material is clayey till, till covered in many places by slag (at northern end), broken concrete, dolomite blocks and various types of debris
	e-dolomite blocks (revetment)	f-sheet-steel piling (bulkhead)		
3. BEACH	a-0 to 5 ft., cobbles and pebbles	b-5 to 10 ft., pebbles and cobbles	c-no beach	d-0 to 8 ft., gravel,broken concrete, stone, wood, junk
	e-5 to 10 ft., beach is gravel,slag, bricks,junk and iron	f-no beach less than 5 ft.,slag, pebbles, junk		

T.3N., R.23E., Sec.28

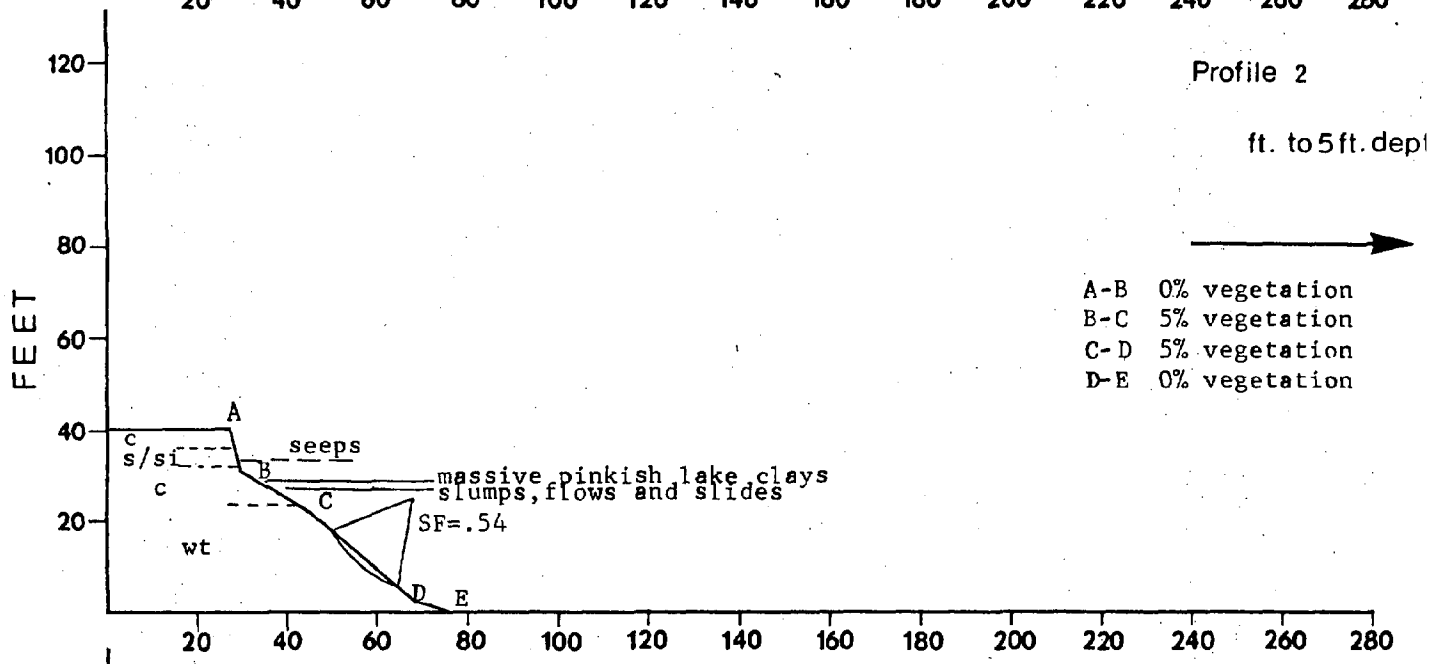
Profile 3



ft. to 5 ft. depth

A-B 10% vegetation
B-C 10% vegetation
C-D 15% vegetation
D-E 0% vegetation

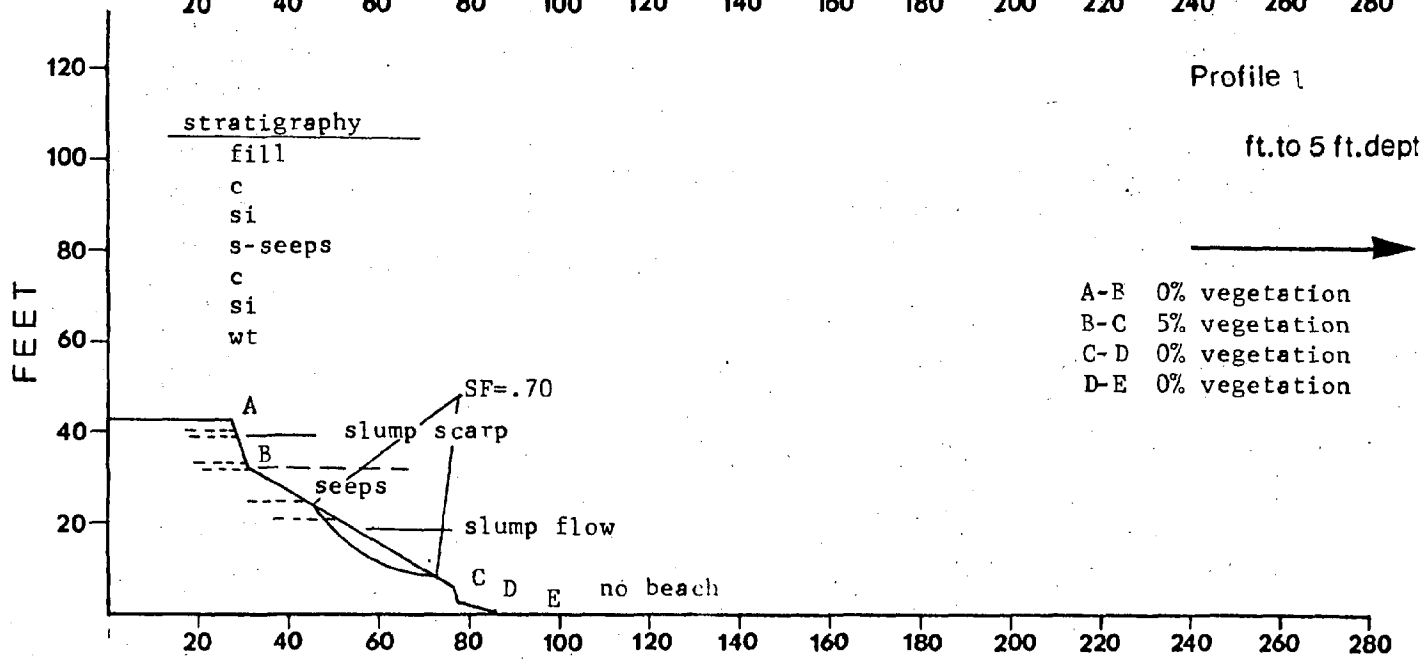
Profile 2



ft. to 5 ft. depth

A-B 0% vegetation
B-C 5% vegetation
C-D 5% vegetation
D-E 0% vegetation

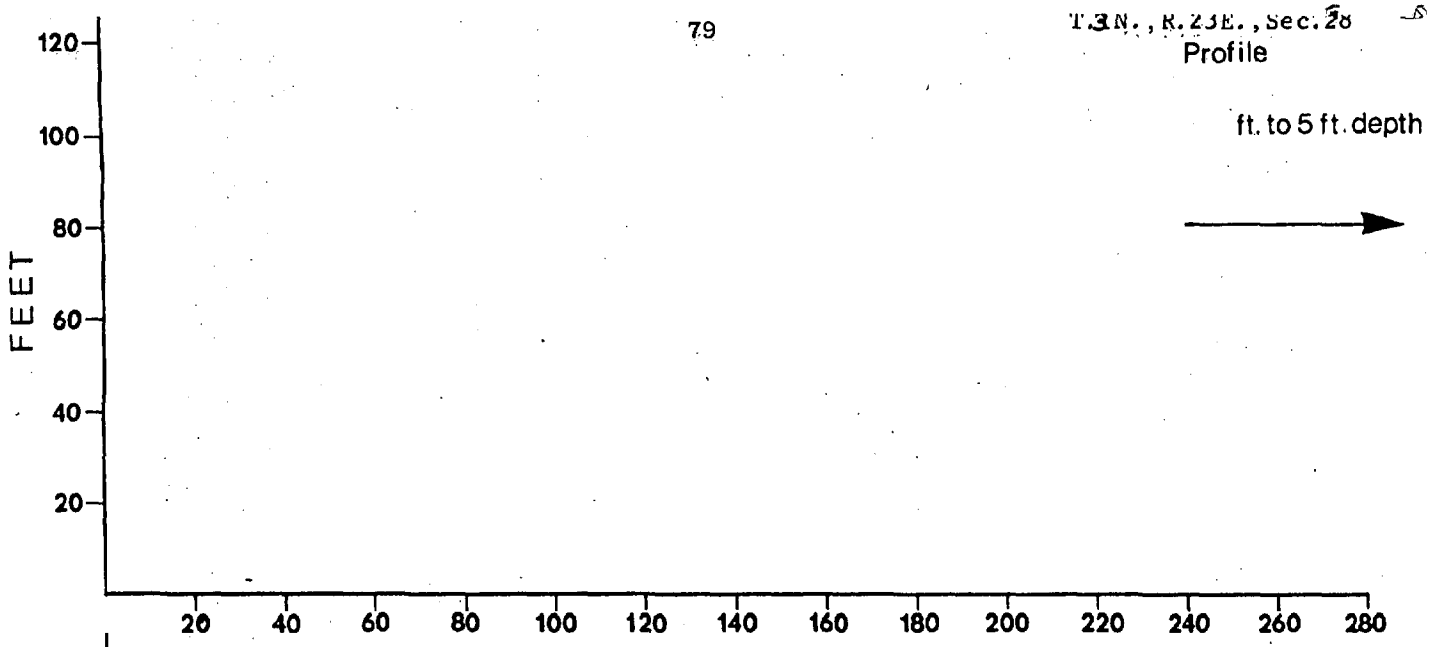
Profile 1

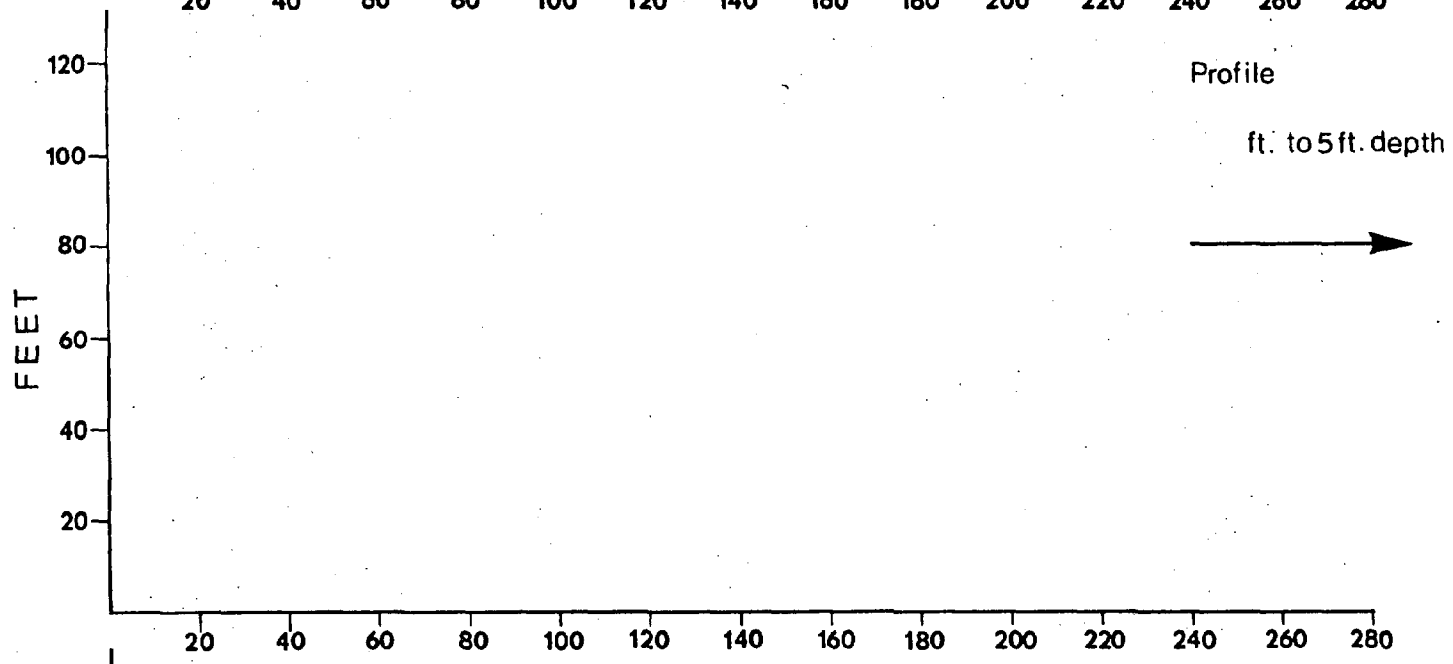


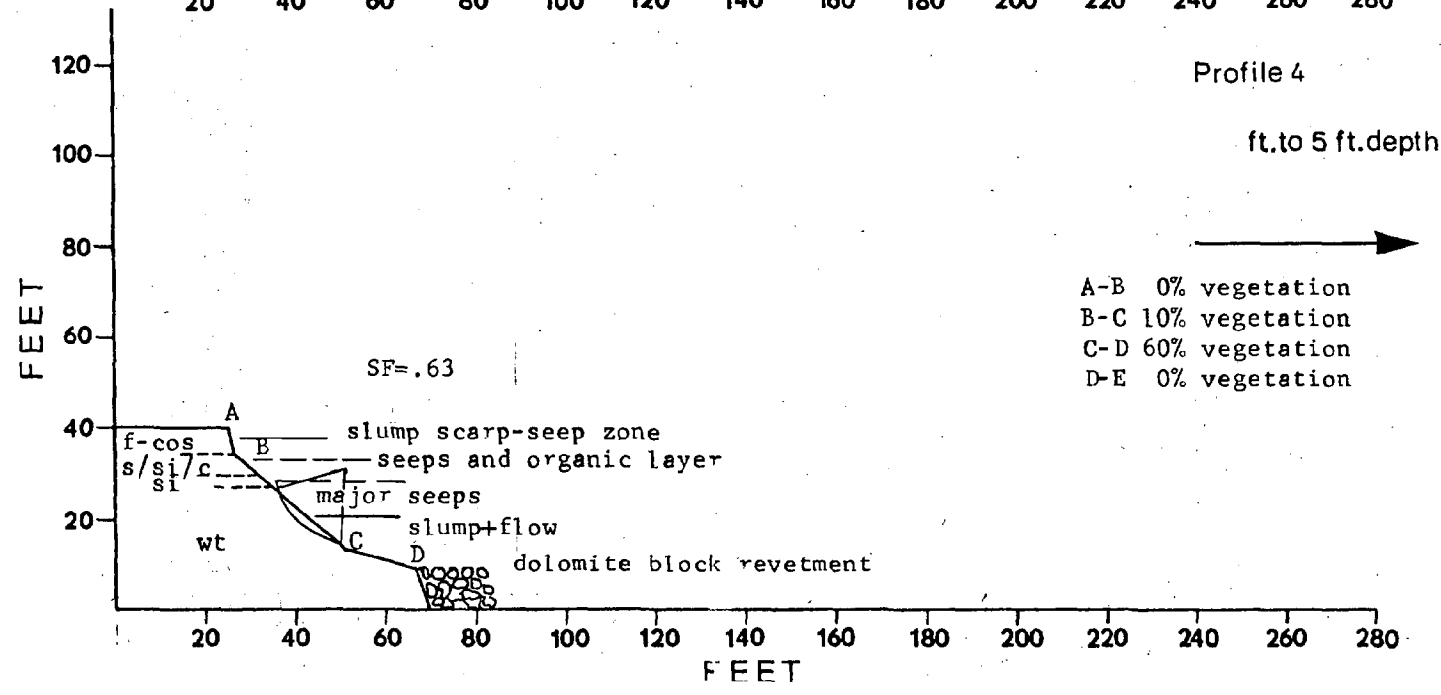
ft. to 5 ft. depth

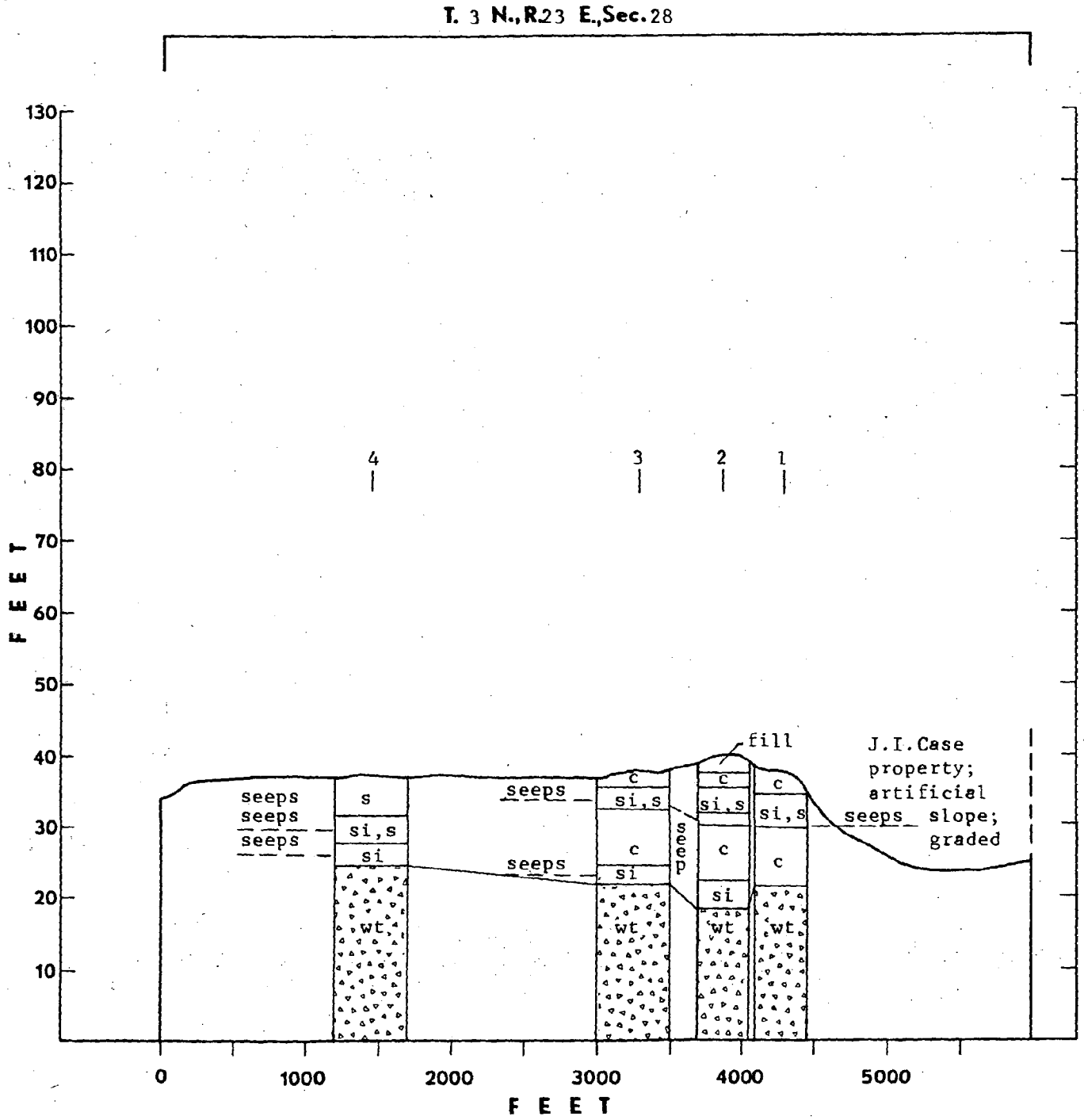
A-B 0% vegetation
B-C 5% vegetation
C-D 0% vegetation
D-E 0% vegetation

T.3N., R.23E., Sec. 28








T. 3 N., R.23 E., Sec. 28
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
4
3
2
1
seeps
seeps
seeps
s
si,s
si
wt
seeps
seeps
c
si,s
c
si
wt
sep
fill
c
si,s
c
si
wt
c
si,s
c
wt
seeps
J.I.Case property; artificial slope; graded
0
1000
2000
3000
4000
5000
FEET